SCIENTIFIC AMERICAN
No. SUPPLEMENT 866

Copyright by Munn & Co., 1892.

Scientific American Supplement, Vol. XXXIV. No. 866. NEW YORK, AUGUST 6, 1892. Scientific American Supplement, $5 a year.
Scientific American, established 1845. Scientific American and Supplement, $7 a year.

OIL ENGINE AND LAUNCH.

MESSRS. PRIESTMAN BROTHERS, London and Hull, have now adapted their engine to marine purposes. Out of this has grown the introduction of the system into a launch, in which we recently made a very successful run. This boat, which is now running on the Thames, is 36 ft. long by 7 ft. 3 in. broad by 4 ft. 6 in. deep. The propelling power is a Priestman marine oil engine, of 10 nominal horse power, which runs at a speed of about 240 revolutions per minute. The engine is illustrated at Fig. 1, the launch being shown at Fig. 2. The engine has two cylinders 9 in. diameter by 9 in. stroke, and the explosions are arranged to take place in each cylinder alternately. Ordinary mineral oil is contained in a reservoir at the base of the engine, and is forced, by means of a small air pump, through a spraying device into a chamber which is maintained at a high temperature by means of the heated exhaust products as they leave the cylinder. In this chamber the oil is vaporized and mixed with air, and is drawn into the cylinder at the out stroke of the piston, compressed to about 25 lb. on the square inch and ignited by an electric spark, thus putting the engine in motion. The speed of the engine is regulated by a direct acting governor, which cuts off part of the charge according to the amount of work performed. A simple means for reducing the speed of the engine is also added, so that the boat is under complete control when landing passengers, etc., or when required to run slower than the speed at which the governors allow same to run. The engine runs in one direction only, but the propeller is coupled to a very simple arrangement whereby the direction in which the boat runs can be reversed by simply turning a small hand wheel. The boat can also be allowed to lie at rest without stopping the engine, the governor controlling its speed until the propeller is put into gear again by means of the hand lever. The whole of the working parts are quite accessible. The pistons are self-lubricating, and there are no slides to get out of order. The igniting device is simple and positive. The cost of running these engines is stated to be about one-half penny per brake horse power per hour. About 40 gallons of the oil is stored in the stern of the boat, and the working cistern in the base of the engine can be supplied from this with oil while running, so that the arrangement is cleanly and gives no trouble. Messrs. Priestman are to be congratulated on having succeeded in introducing a means of obtaining motive power from heavy petroleum having a high flashing temperature, as against oils of low flashing point, which are dangerous. The launch in question is stated to be the first on the Thames running with the safe mineral lamp oil.—*Iron.*

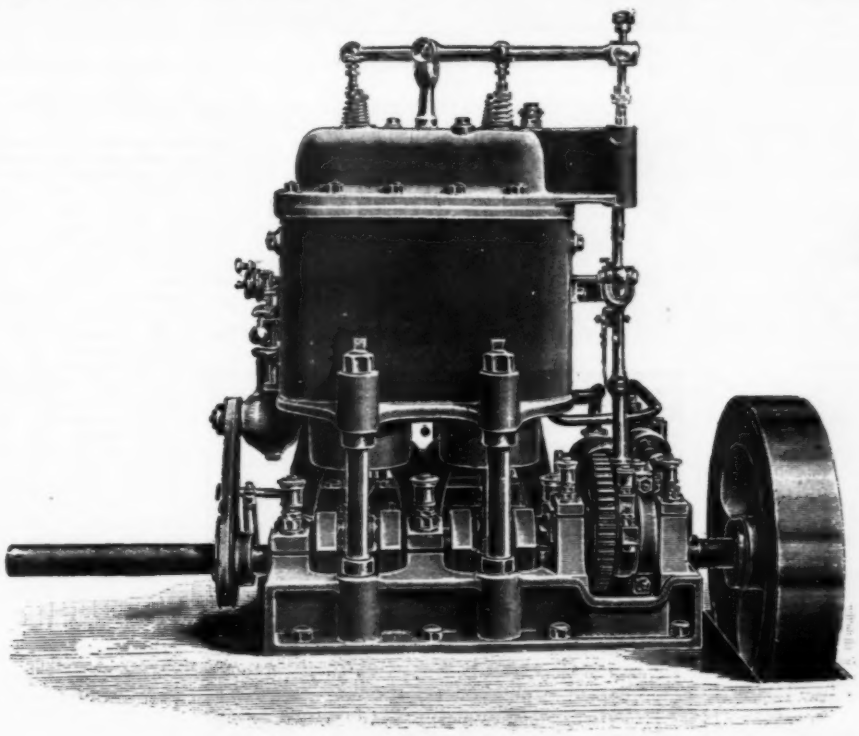


FIG. 1.

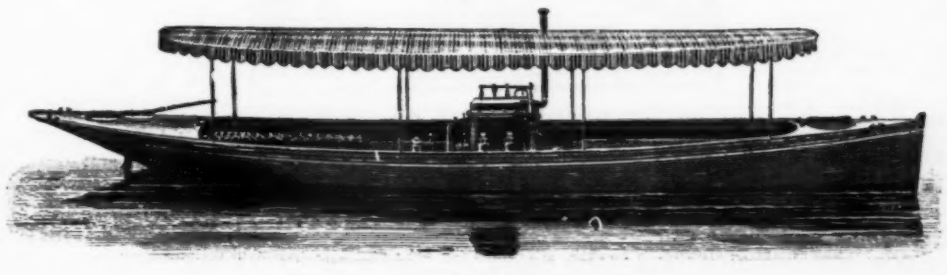


FIG. 2.

THE PRIESTMAN MARINE OIL ENGINE AND LAUNCH.

THE PNEUMATIC MOTOR FOR SURFACE ROADS.

By HERMAN HAUPT.

IN view of the serious objection to the trolley electrical system for propulsion of cars on surface roads in cities, the annoyance from tearing up streets and the cost of plant and maintenance of the cable lines, the expense of horse power, with the sanitary evils resulting from the location of stables in populous cities, the fact that pneumatic motors, after a successful demonstration of their superiority, have been overlooked seems inexplicable.

These motors are not only entirely free from the objectionable features of the other systems, but they furnish a mode of propulsion which is more safe and also more economical than any other, with equal velocity of travel.

These assertions are made advisedly and are based on actual demonstration. In 1878 and 1879, five pneumatic motors were constructed upon the plans and under the supervision of James T. Hardie, mechanical engineer, and were run for several months on the Second Avenue Railroad in New York, with perfect success.

In 1879, the writer was called upon in the interests of proposed investors to investigate and report upon the practicability and expediency of using pneumatic power for street railroads. The comparative results were overwhelmingly in favor of motors of that class, but all attempts to secure their general introduction at that time proved failures. The position taken by presidents and other officers of horse railroad companies, both in New York and Philadelphia, was that any car running along city streets without horses in front would frighten horses, cause runaways, accidents, and subject companies to suits for damages.

This objection of course applies with much greater force to the cable and trolley systems, which are accompanied by a loud humming noise, while the pneumatic motor can have a noiseless exhaust, but no argument or explanation availed in the face of this senseless and ridiculous objection. One railroad president declared that if the motor were adopted by his company it would be necessary to kill some of his old horses, stuff the skins, and mount a pair of them on a low truck in front of each car.

The attempt to introduce pneumatic motors was thus found to be premature in 1879. The company could make no progress and finally abandoned all efforts, losing the capital expended in plant and demonstrations, and no attempt to revive the motor has since been made. The engineer and inventor, Robert Hardie, is now in the service of the mechanical department of the Columbian Exposition at Chicago, and retains unshaken confidence in the superiority of the pneumatic motor.

Existing conditions now seem favorable for the introduction of a motor which, free from the objections to all other systems, with no new defects of its own, may be considered as perfect. No fears are now entertained that a car running without horses in front will make a stampede of all equine animals on the streets traveled, and this in 1879 was the only reason urged in opposition to the introduction of the pneumatic motor. It is possible therefore that a few extracts from the report made in 1879 may be of interest at the present time.

The compressor plant was located at Harlem, on the line of the Second Avenue Railroad. It developed 66 horse power and charged the cylinders under a car with compressed air in seven minutes. With a proportionately larger plant not more than one minute would be required.

The report of Mr. Hardie stated the capacity of the cylinders under the seats at 17,000,000 foot pounds of work, capable of running a car 16 miles on a level.

The effect of the compressed air was greatly increased by passing the air through a tank of hot water at temperature due to 80 pounds pressure. The tank had a capacity of 5 cubic feet and was placed on the side of the platform.

The writer has not at hand a copy of his full detailed report, but only an extract of some of the results, which will be here given.

A duty of nearly 50 per cent. of the horse power used in compressing air can be secured from the expansion and utilization of dry air when compressed; and by using stationary, compound, or condensing engines, four times the power can be obtained with a given cost of fuel, as compared with ordinary steam motors, which more than counterbalances the loss in compression.

By the addition of a heater and passing the air through hot water, an increase of nearly 100 per cent. of power can be secured at a merely nominal cost.

On a straight and level road, with 160 cubic ft. of air in the reservoirs, under an initial pressure of 350 pounds, the motor would run 7 miles with a reserve of one-third left in the reservoirs on its return. This result assumes that the amount of air expended at each stroke is equal to a full cylinder of air expanded to atmospheric tension, but actual work has demonstrated an ability to run 10 miles with a single charge, proving that less than this quantity is sufficient. The back pressure which would result from working against a vacuum is relieved by suction valves in the exhaust passages.

In descending grades, the motor cylinders not only act as brakes, but also as air pumps, and have power to pump back into the reservoirs, against a pressure of 200 pounds, sufficient air to raise the gauge pressure 7 pounds in running 2,100 ft., and restore sufficient air, when heated, to run the motor half that distance upon a level.

By this remarkable contrivance power can be stored on descending grades. The down hill portions not only use no power, but give back a portion of that which was expended in ascending.

The compressed air can be used expansively to any extent, and cut off at any part of the stroke. It can act as a brake, or the motion can be instantly reversed, and the braking apparatus is exceptionally complete and satisfactory.

The power of an eight-ton motor is sufficient to propel three cars on a straight and level road. With full power in the motor cylinders, and full adhesion on the rails, the motor can overcome grades of 300 feet to the mile.

Although, during a run, the pressure in the reservoir is constantly diminishing, yet by means of a reducing valve the working pressure in the motor cylinders is maintained at a constant limit.

Each motor, allowing for increased speed, would take the place of ten or fifteen horses, the cost of which would about equal the cost of the motor, $1,500.

The system would be particularly adapted to suburban localities and would afford better facilities for rapid transit than are afforded by elevated roads, for while the speed would be equal to twenty miles or more per hour, the stops would not be limited to stations, but could be made at any point.

With the small class of motors, three cars, or two in addition to the motor, can ascend grades as steep as any usually found on horse railroads. This is a point of the greatest value for public accommodation. It will enable a company to utilize all their old cars and supply additional cars at the hours when the rush of travel requires them without additional expense for power or conductors.

The Delamater iron works offers to supply a compressor plant of sufficient capacity to charge one car per minute for $20,000.

Compressed air can be transmitted to any distance without loss except for friction in pipes. If pipes are large and velocity low, the loss will be inconsiderable. Several lines could therefore be operated from a large central plant, and in many localities natural water power could be utilized to compress air, and the compresed air transmitted by pipes to large motors, generate electric currents, or drive machinery by direct application to cylinders.

To charge motors at a central station a nozzle between the tracks and a short piece of pressure hose to screw on to the air reservoir is all that would be required to connect with reservoirs located in a building. It need not be necessary to run the cars into a house to renew the air supplies.

The running expenses are less than one-half, in fact, the estimate shows less than one-third, the cost of horse power.

The motors run without noise, ashes or smoke, are perfectly under control, and would furnish the best possible power to operate elevated railroads.

Skilled engineers are not required, an ordinary car driver can be taught to run an engine in a single trip.

No fuses are burnt or boilers exploded through carelessness, and as air reservoirs last indefinitely, explosion in transit from causes which render steam dangerous is impossible.

Even if an explosion should occur by a rupture, it would be while charging the reservoir at the time of maximum pressure, and not in transit, and the air would simply escape with a hissing noise. Cold, not heat, would result from the expansion.

The car acts as its own governor, and as no more air can be used than is necessary to overcome the resistance, there can be no waste.

There are no horses in front to obstruct a clear view of the track.

At a speed of 12 miles per hour, the motor can be stopped on a level within its length, and the braking apparatus cannot get out of order so long as the motor can move at all.

The pneumatic motor would be peculiarly adapted to underground roads, as the escape of pure air would assist in the ventilation. But it is the best possible for all urban or suburban roads, whether elevated, surface or in tunnels.

In this paper, results only have been given; the full report made in 1879 gives the facts upon which the conclusions have been based.

A detailed estimate was made from data furnished by the operations of the Second Avenue Railroad and a comparison of costs of operation by horse power and by pneumatic motor. In this estimate it was assumed that a compressor plant was located at each end of the route, requiring double the expenditure for plant and double the expense of operation over a single plant located in the middle of the run, which would answer just as well.

The estimate for pneumatic power was designedly made in excess, so that errors would be on the safe side, and the cost of horse power was from actual results on the Second Avenue Railway.

On the basis of sixteen millions of passengers carried on this road in 1878, the year prior to the report, the actual results of operation by horse power were:

Running expenses per passenger in cents,	2·88
Estimate by pneumatic motor.....	0·89
Cost per passenger by horse power including general expenses and a six per cent. dividend.....	4·55
Estimate by use of pneumatic motor.....	2·57

The dividend was $72,000, or 0·45 of a cent per passenger.

The conclusion from the data furnished was that a very small increase in the number of passengers would permit the company to sell ten tickets for 25 cents and still pay fair dividends upon the capital invested, besides furnishing a rapid transit, the speed of which would be limited only by considerations of safety.

But all these demonstrations and representations backed by the very strongest inducements of the daily press in New York and by the actual running of five motors daily for a period of several months availed nothing against the senseless cry "It will scare horses." "The motor cannot be run unless we put stuffed horses in front of each car." It is true that horses on the opposite track did at first prick up their ears, look at the motor and shy a little, but they never gave any trouble and soon became accustomed to it, and no case of a runaway accident with street vehicles was heard of. But prejudice, which proved all-powerful to exclude the pneumatic motor at that time, did not prevent the introduction of the far more objectionable trolley and cable systems very soon afterward.—*Street Railway Review.*

[FROM ENGINEERING.]

A SHORT HISTORY OF BRIDGE BUILDING.*

By C. R. MANNERS.

IN the course of publishing the very interesting sketches of bridge construction by Mr. C. R. Manners, we have received letters from various correspondents containing drawings and particulars of typical and historical bridges not referred to in the articles, which of course laid no claim to completeness. We think that some of them are of sufficient interest to be reproduced, and we shall be glad to receive other examples for publication.

The first of these, for which we are indebted to Mr. G. Porter, of Lincoln, is a view of the High Bridge, Lincoln. This fine old structure, which dates from

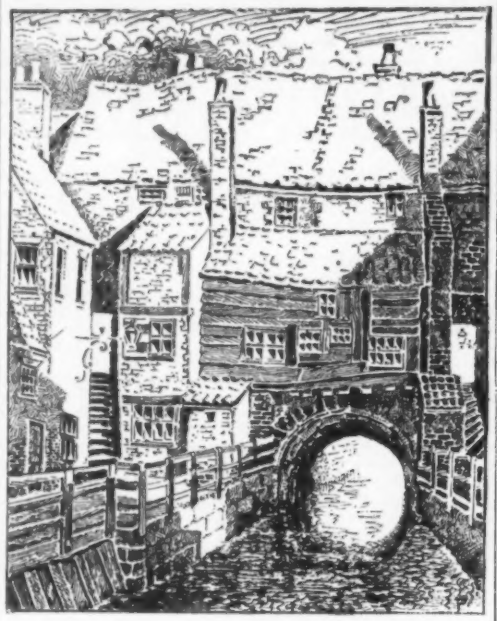


FIG. 86.—HIGH BRIDGE, LINCOLN.

1220, is a good example of the transitional period, with Norman semicircular arches and early English mouldings and groined vault. It is one of the few old bridges remaining in England with houses upon it; the sketch shows the west side of the bridge and the very picturesque backs of the old houses. A second sketch of the same bridge shows the elaborate groining of the vault and the method of arching adopted by the bridge builders of the twelfth century; the span is 21 ft. and the height 11 ft.; the sketch also shows the pointed arches by which access is gained from the street level to the river, by the narrow, uneven flights of steps on each side.

A third drawing illustrates Shire Bridge, at Clay-

FIG. 87.—GROINED ARCH OF LINCOLN BRIDGE.

pole, near Newark, over the Witham. This was built in the reign of Henry VII., and is a good example of the Tudor or depressed arches in brickwork. Near this bridge is a wheelwright's cottage, which is all that remains of a fine old mansion—Water Hall—which formed Oliver Cromwell's headquarters before he invested Newark.

Next follow a description and illustration (Figs. 89 and 90) of a pontoon bridge that crosses the harbor of St. Anne's, Curacoa; these particulars were furnished us by Mr. H. J. Cook, 13 Victoria Street, Westminster:

"This harbor is one of the most convenient in the West Indies, some of the largest ironclads being enabled to steam up into an inner harbor, where a small fleet can lie securely hid from view. It divides the town into two unequal portions, and great inconvenience was frequently felt in getting the traffic from one side to the other, a great deal of which, as well as the passengers, was ferried across in flat square-ended boats skillfully handled by negro boatmen.

"The width at the spot where the pontoon is placed is about 700 ft., and 200 ft. from the western shore is built a pier, on which is a turntable about 20 ft. in diameter, and on this pivots the length of 500 ft. The pontoons are each about 26 ft. long and 10 ft. wide, and spaced about 30 ft. apart from center to center; on each are fixed five cast iron rockers or cradles supporting the roadway, which is of timber, trussed with iron rods, the railing being of gas piping; the 500 ft. length is

FIG. 88.—SHIRE BRIDGE NEAR NEWARK.

supported on fifteen pontoons, the end one furthest from the turntable being fitted with screws at each end worked by an engine by which it is opened and closed; as it is sometimes not found necessary to have the whole 500 ft. opened, an arrangement is made by which only 200 ft. is opened on a simple hinge about 2 in. in diameter. Should heavy weather be coming on, the whole length of 500 ft. can be unshipped in a few moments and floated alongside the shore; it scarcely takes a minute to open for the full width, so that no delay is caused to vessels entering or leaving. The total cost, I understand, did not exceed 5,000*l.* Figs. 89 and 90 will give some idea of it."

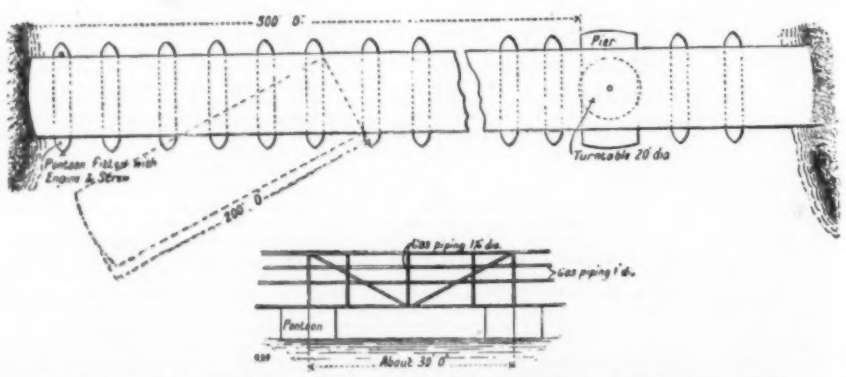
Mr. Manners writes us: "Only a few weeks ago some Greek papyrus were discovered in mummy foot cases, which, when examined, show that timber beams were much used for bridge building at an early date. Among the papyrus was a letter from a civil engineer named Alexander, to his master Kleon, inspector of public works. He says that in a canal leading from Tehetuns and Samaria to Kerkeesis, which was dug last year (254 B. C.), a stoppage had taken place and asks 200 drachmæ from the salt tax of the place for repairs, and then, evidently having much to do in erecting bridges across various canals, he adds: 'Send me also the remainder of the 200 logs of timber as long and thick as possible, that we may have them for girders for our bridges. For want of them we are hindered, but if you have more, 200. Farewell. Year 21, Payni 16;' being about August, 253 B. C."

MIRROR FOR LAYING OUT STRAIGHT LINES.

WHEN it becomes necessary to make a plan of a space covered with water, such as a lake or river, or to map a gulf, bay, fjord, or estuary, the position of each sounding is fixed by taking with a sextant the angle under which a certain number of reference points upon the shore are observed from such position. Each of these points is afterward traced upon the paper according to the geometrical construction of the segment capable of a given angle—an operation that is quite lengthy, often inconvenient, and not very accurate when the distance is great and the angle very acute, and which must be repeated at least three times for each point.

It is found advantageous to arrange the soundings in a straight line. Not only are the bearings of the land more regular, but a single new co-ordinate then suffices to fix each point. Upon the Swiss lakes the stadia is employed. An operator standing upon the shore keeps the boat in the direction desired by means of signals, and while the lead is being heaved he measures, by means of the stadia, through an observation of a divided mast carried by the boat, the distance of the latter from land. If occasion requires it, a measurement by the sextant, made from the boat, will serve as a verification.

Again, but a single observation by the sextant may



FIGS. 89 AND 90.—PONTOON BRIDGE IN ST. ANNE'S HARBOR, CURACOA.

* Continued from SUPPLEMENT, No. 856, p. 13675.

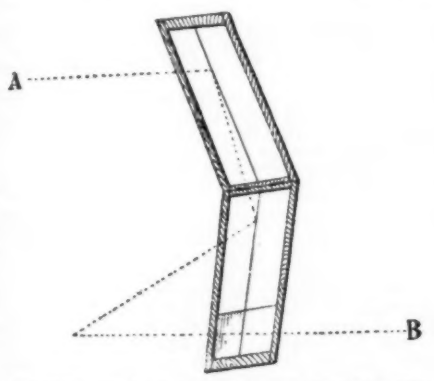
be made of two reference points, but the necessity of preserving a definitive alignment forces the operator in the boat to remain in constant communication with a second operator located on the shore. Now, it is often necessary to be in a position to act alone. During a recent study of lakes Gerardmer, Longemer, and Retoumemer, in the Vosges, I had at my disposal only the aid of simple maneuvers which I should not have dared to rely upon for accurate work. I was, therefore, led to try to solve the following problem: to place myself in alignment with two fixed reference points, one situated in front and the other behind.

The instrument devised to this effect consists of two rectangular mirrors 13 centimeters in length by 4·2 in width, connected widthwise by a hinge. The first mirror is completely silvered, while the silvering of the second is removed at its lower extremity, so as to leave the glass transparent for a space of $2·5 \times 4·2$ centimeters. An aperture in the box serving as a mounting for the mirrors corresponds to this transparent portion.

Finally, each mirror is provided in the center, parallel with its long side, and corresponding exactly upon each—on the silvered and the transparent portion, with a straight line traced with a diamond and colored black or red in order to render it more visible.

Let us suppose the observer in a boat, between two reference points, one situated in front and the other behind, and with which he wishes to put himself in alignment. Turning his back to the point, A, and holding the double mirror open vertically in front of him at the level of his forehead, he arranges his eye in such a way that the image of the red line of the upper mirror shall, through reflection, exactly cover the red line traced upon the lower one. He then turns his head so that the image of the point, A, reflected in the upper mirror and seen after a second reflection in the lower mirror, shall coincide with the two red lines blended into a single line. He directs the oarsman to shift the boat to the right or left until, while remaining in the same conditions, he perceives, through the transparent mirror by direct view, the second reference point, B, in coincidence with the red line. He is then exactly upon the line that joins A and B, and it requires but a single measurement with the sextant, and consequently a single construction on the plan, in order to fix the position of the point.

There exist several instruments designed to erect a perpendicular upon a given line, that is to say, to measure an angle of 90°, which is afterward doubled



MIRROR FOR LAYING OUT STRAIGHT LINES.

in order to obtain one of 180°. Some can be used only upon *terra firma*, while others have too small a field, and require a stability and convenience of manipulation impossible to find in a boat. The conditions of a survey upon water are very different from those of a survey on land. The mirror that has just been described has a wide field, an indisputable advantage in these sorts of operations, and which renders the sextant so valuable. It is sufficiently accurate, cheap, and not complicated and therefore not very apt to get out of order. Its dimensions permit of its being carried in the pocket. It dispenses with an assistant on land, and in the office it saves much time by simplifying the production of the plan. I have employed it, and I believe that it will render service under circumstances similar to those in which I was placed.—*J. Thoulet, in Le Genie Civil.*

DECORTICATING RAMIE.

THIS is the invention of C. Girard, of Paris, France, and relates to a chemical process for decorticating and ungumming textile fibers, more especially ramie or china grass, and it consists, broadly, in the employment for these purposes of basic salts of polyatomic acids, such as basic borates, phosphates, arseniates, tungstates, molybdates, and more particularly basic manganates, stannates, or alkaline silicates, either in the cold, or by boiling, or under pressure, the result of the reaction, whether decorticating or ungumming, depending on the quantity of the product employed.

The action is much more rapid and effective than when caustic alkalies or alkali carbonates are employed, as the salts above referred to quickly disintegrate the pectates of the earths and alkaline earths by dissolving, especially when the operation is performed hot, a considerable quantity of cutose and pectose. The vasculose remains in the form of a thin, non-adherent pellicle, which is readily removed by washing or slightly beating the fibers after drying.

The salts above mentioned do not injure the fibers, which retain their fineness, suppleness, and luster.

If using manganates (with which good results have been obtained) as an example of the process of this invention, the operation is performed in the following manner:

Into a boiler of a capacity of 350 gallons are placed 220 pounds of ramie or china grass, to which is then added a solution of manganate of potash or soda, in the proportion of 15½ pounds manganate to 1,100 pounds of water. The proportion of manganic acid to alkali should be about one to four, as a larger proportion of manganic acid would burn the fiber and entirely deprive it of its tenacity. The whole is then boiled for from two to five hours, according to the kind of ramie to be ungummed. At the end of this time the gums are completely acted on, and the color of the fiber varies from brown to black, due to the deposit of manganese oxides. On leaving the bath the fibers are washed in water and then passed through a bath of sulphurous acid to dissolve the manganese oxides deposited, after which they are thoroughly washed to entirely eliminate the manganese salt formed.

The fiber thus treated is now ready for use and may be bleached by means of hypochlorite of lime and soda. The fiber which has been ungummed by this process is very silky and retains its suppleness and tenacity.

The proportion of alkaline manganate employed may be increased or reduced according to the quantity of the ramie to be ungummed.

It is to be observed that basic salts of polyatomic acids may give the same results. In this case it is preferable to increase the quantity of the salt, which should be in the proportion of about 10 per cent., and hydrochloric or sulphuric acid should be substituted for sulphurous acid. The heating may also be performed under pressure. By heating the ramie stalks in the cold or urging when the hot process is employed, and employing a much smaller proportion of the basic salt of a polyatomic acid, the fibers may be decorticated or detached with the greatest facility from the woody portion.

LAMP BLACK AND BONE BLACK.

By HENRY J. WILLIAMS, Chemist.*

WHEN combustible bodies such as wax, fat, coal gas and other hydrocarbons undergo combustion, the hydrogen which these substances contain is the first element to undergo oxidation or be consumed, while the carbon, especially if the flame be suddenly cooled by bringing a cold surface in contact with it, may almost entirely escape combustion and be deposited. When the burning substance is very rich in carbon the flame may smoke without being cooled, and it will do so all the more strongly, the less the supply of air present. This simple fact is the basis which underlies all processes for the manufacture of finely divided carbon or lamp black.

Lamp black is obtained on a large scale by collecting the smoke produced during the imperfect combustion of oils, fats, resins, coal gas, tar, wood tar, petroleum residues, dead oil, soft woods of the nature of pine, pitch pine, and even bituminous coal. These substances all yield lamp black of various grades of quality. The operation is quite simple and consists merely in consuming all the constituents of the burning body except the carbon and preserving as much of that as possible. Lamp black is prepared in large quantities, by the manufacturers of turpentine, from the impure resins and other refuse matters that remain after the distillation of the turpentine. These are burned in iron pots or furnaces supplied with a very limited access of air, the dense smoke produced by the combustion being conveyed into chambers hung with sacking, upon the surface of which the lamp black is deposited. It is scraped or shaken off from time to time.

The accompanying illustration shows the arrangement of the apparatus generally used. It consists of a cylindrical brick chamber ten or fifteen feet in diameter, provided with a conical roof which has a small opening near its apex, sufficiently large to maintain a slight draught and which causes the smoke to ascend toward the upper part of the chamber. A cone of sheet iron hangs within the cylinder and this too has a small hole at the top to allow the gases to escape. At the side and base of the chamber there is a kind of furnace, above the fire of which is placed a pan containing resinous or fatty matters, which are heated to a point sufficient to convert them into vapor. Then this vapor undergoes sufficient combustion to deprive it of its hydrogen, while most of the carbon remains unconsumed. The smoke ascends into the chamber and is mostly deposited upon the hanging canvas or sacking which covers the walls and upon the inner surface of the iron cone, from which it falls after a certain thickness has been collected. The cone is so held by a chain and pulley that it may be raised or lowered, which operation scrapes the lamp black off the sacking. The lamp black thus prepared is not pure carbon, as it is mingled with resinous and bituminous substances, together with ammoniacal and other matters. By heating it to full redness in retorts which are air tight, nearly all these impurities are driven off and an almost pure impalpable black powder remains.

In most cases the process just described is slightly modified, and not only ordinary lamp black but the better grades too are obtained at the same time. This is brought about by interposing between the fire place and the soot chamber just described a brick work gallery or flue fourteen feet long in which the inferior tarry material deposits itself. A series of chambers or condensers may follow in which the successive deposits increase in fineness and value until the last chamber, which contains the conical hood, receives the finest lamp black of all.

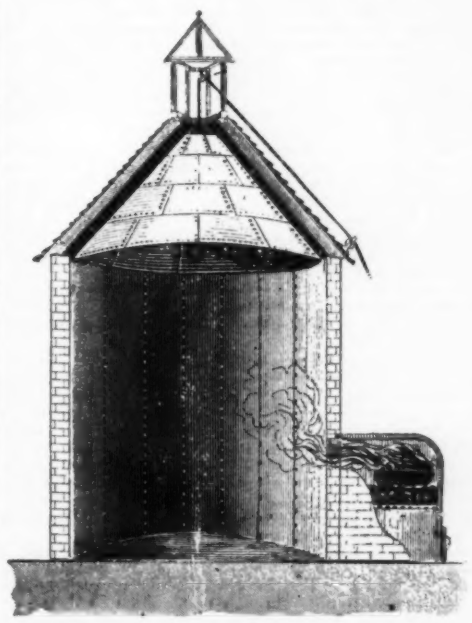
By another process gases are burnt with an insufficient supply of air while a metallic cylinder, generally made of tin, revolves in the flame and cools it sufficiently to bring about an abundant deposition of lamp black. Of late years large quantities of lamp black have been manufactured in this way from natural gas, at Pittsburg, Pa. The lamp black is brushed off automatically as the cylinder revolves. Other kinds of black are made and used in the arts, such as Spanish black, which is made from cork; vine black from vine tendrils, and peach black, which has a bluish color, from peach kernels. Good lamp black should be impalpable, free from dirt and much moisture, and should leave little or no ash on combustion.

Bone black, also called animal charcoal and sometimes ivory black, is a black carbonaceous powder obtained by grinding the product of bones burned at a red heat in closed vessels. The name ivory black should be properly limited to the finer and more expensive article prepared from ivory dust or turnings. When bones are subjected to heat during the process of making bone black, certain volatile products are given off, consisting of an empyreumatic oil, fetid gases and ammoniacal vapors. The ammonia may be collected, but the other products are generally burned. The fixed product which constitutes bone black consists approximately of:

Phosphate of lime	78	per cent.
Phosphate of magnesia	1·5	"
Carbonate of lime	8·5	"
Carbon	10	"
Impurities, silica, iron, etc.	2	"
Total	100·0	"

The powder resembles that of vegetable charcoal, but is more dense and less combustible, while its ashes are less soluble in sulphuric acid than those of charcoal. The process of making bone black varies according as the ammonia vapors are saved or allowed to go to waste. In the former case the bones, freed from fatty matter, flesh and tendons, are carbonized in closed retorts of fire clay or cast iron, in furnaces not unlike those used in the manufacture of coal gas. A connection with the condensing apparatus is made by means of 3 in. pipes, but the volatile products, aside from ammonia, are either allowed to escape or discharged under the fire, where they afford heat and save fuel, while their offensive odor is destroyed. When the retorts have been subjected to a red heat for thirty-six hours the charred bones are raked, while hot, into a box, which is then hermetically closed till they are cold. They are then ground in mills.

The better quality of bone black, however, is made by the second process, where the volatile products are entirely disregarded. Here the bones are placed in



INTERIOR OF SOOT CHAMBER FOR THE MANUFACTURE OF LAMP BLACK.

cast iron pots containing each about twenty-five pounds, which are then placed together in pairs mouth to mouth and luted with clay. These pots are then piled in columns, to the number of 100 or 150, in a sort of kiln, the entrances to which are tightly bricked up except those for the admission of the flame and opening into the chimney. The pots are well heated for sixteen to eighteen hours by the flame playing around them and the heat is increased by the combustion of the combustible vapors which issue from the bones. Finally the contents of the furnace are allowed to cool and the pots are taken out, and when thoroughly cold opened and the product ground.

Good bone black should have a dull even black color on fracture, and should cling when applied to the tongue; where the grains have a glistening appearance the quality is not so good. A charge of bones yields about 50 per cent. of its weight in the form of bone black.

The quality and depth of shade of both lamp black and bone black are generally judged by mixing a certain weight of either with a known weight of dry white lead and comparing the resulting shades with those obtained with similar proportions of standard lamp blacks or bone blacks.—*India Rubber World.*

BLUE BRASS.

A COLD method of coloring brass a deep blue is as follows: 100 grammes of carbonate of copper and 750 grammes of ammonia are introduced in a decanter, well corked, and shaken until solution is effected. There are then added 150 cubic centimeters of distilled water. The mixture is shaken once more, shortly after which it is ready for use. The liquid should be kept in a cool place, in firmly closed bottles or in glass vessels, with a large opening, the edges of which have been subjected to emery friction and covered by plates of greased glass. When the liquid has lost its strength, it can be recuperated by the addition of a little ammonium. The articles to be colored should be perfectly clean; especial care should be taken to clear them of all trace of grease. They are then suspended by a brass wire in the liquid, in which they are entirely immersed, and a to-and-fro movement is communicated

*Member British Society of Chemical Industry, Deut. Chem. Gesell., and Am. Institute of Mining Engineers.

to them. After the expiration of two or three minutes they are taken from the bath, washed in clean water, and dried in sawdust. It is necessary that the operation be conducted with as little exposure to the air as possible. Handsome shades are only obtained in the case of brass and tombac—that is to say, copper and zinc alloys. The *Chemical Trades Journal* says the bath cannot be utilized for coloring bronze, copper-tin, argentine, and other metallic alloys.

A FATAL THUNDERBOLT AT BOURGES, FRANCE.

Among the atmospheric phenomena, storms and the electric manifestations that accompany them offer a very peculiar interest, and necessarily rouse the attention of the meteorologist to the highest degree. During stormy weather thunderbolts are often very frequent and play a much more important role than is commonly believed in the series of disasters and scourges of which mankind is so often the victim on the part of the natural forces.

Lightning produces extraordinary effects, which perplex physicists and which it would be impossible to explain.

We see it fusing metals without burning the organic materials with which they were in contact, displacing heavy objects and tearing fabrics, and that, too, with a character of extraordinary instantaneousness.

A terrible thunderbolt descended near Bourges on the 4th of last May, causing the death of a soldier, and produced under peculiar circumstances, on the subject of which we have made a complete inquiry. We have thought that our readers would read the results of it not without some interest.

On the 4th of May a detachment of eighteen men belonging to the Thirty-seventh Artillery was on its way to the proving grounds in the vicinity of Bourges in charge of Chief Pyrotechnist Beauvais. Suddenly overtaken by a heavy rain storm, the soldiers quickened their pace in order to reach a shelter. All at once there was a burst of thunder of fearful intensity, and all the men were thrown to the ground with the exception of a pyrotechnist who was walking in the rear. The first three ranks arose, but four men remained unconscious. These were lifted and carried to the hospital, where every attention was given them. Three of them were restored to life, but the fourth, Francis Bouveau, succumbed. There was a deep gash in his head, and his chest was all burned.

Fig. 1 gives a representation of the catastrophe, made from a photograph taken especially for *La Nature* and reproduced *en cartouche* in No. 1 of the figure. This photograph represents the spot where the bolt fell on the 4th of May. It is at the entrance of the proving ground. The building to the left is the riding school, and a little to the rear in the background are the barracks of the Thirty-seventh Artillery. The men, who posed shortly after the occurrence in the order in which they were marching, are the same ones that figured in the catastrophe. Those behind were particularly affected.

All the men, at the moment the thunderbolt descended, fell face forward. The chief pyrotechnist, Beauvais, who may be seen to the right, outside of the file, and behind, was quite seriously affected. He says that he felt a violent shock at the nape of the neck and in the leg, with a burning sensation. The others who were taken to the hospital gave a similar account. None of the pyrotechnists struck by the lightning saw the flash, but an officer who was in front and was facing them says that the bolt presented itself in the form of a triple flash.

Dr. Dodion, adjutant of the Thirty-seventh, had a photograph taken of the effects of the victims that were destroyed by the fluid, and this interesting picture we reproduce in Fig. 2.

Pyrotechnist Bouveau was struck in the head, and his cap was torn to pieces, the crown and band being held together only by a narrow strip. The hair of his head as well as that of his whole body was entirely burnt off. The discharge passed around his right ear, then over his shoulder, ripped open his sternum, reached his left hip obliquely, passed to his scrotum, followed the interior surface of his left leg, tore his drawers, tore away some of the posterior eyelets of his gaiter in stripping off a piece of leather (which was not recovered), and then passed through his shoe to the heel. The latter was provided with a rim of iron, as may be seen from Fig. 2. This formed an excellent contact with the wet ground, but, as the fluid met with a resistance in the leather of the heel, it loosened it at the point, P. Upon examining the photograph with a magnifying glass, we clearly distinguish all these details, as well as the raggedness of the torn parts, resembling a succession of very irregular saw teeth.

A few storms have also occurred during the present month of June, and thunderbolts have struck here and there, and made numerous ravages. On the 14th of June, lightning struck two houses at Narbonne, and, on the same day, burned a dwelling at Betaille in the department of the Lot. At Couzon, in the same department, lightning killed a woman and seriously injured a little girl. On the same day, at Balaruc, near Cette, it struck twice and killed one of the inhabitants, Mrs. Errere, who happened to be in the middle of a field. Two days afterward, violent storms occurred in the departments of Gard and Aude, and lightning struck in several places. At Cuxac d'Aude, it killed a young man 28 years of age. Finally, it may be added that a dispatch from Chicago apprises us that, on the 16th of June, two men and a woman were killed by lightning in Lincoln Park. It struck the monument erected therein to the memory of General Grant. Some fifty persons, out for a walk, overtaken by a storm, had taken shelter in the galleries of the monument. When the bolt fell, every one was prostrated, and three persons did not rise again.

Such thunderbolts are, in most cases, scarcely mentioned in the local papers, and yet they are always accompanied with facts worthy of being recorded, and which, were they known, would supply elements of observations of great value to physicists and meteorologists.—*Le Nature.*

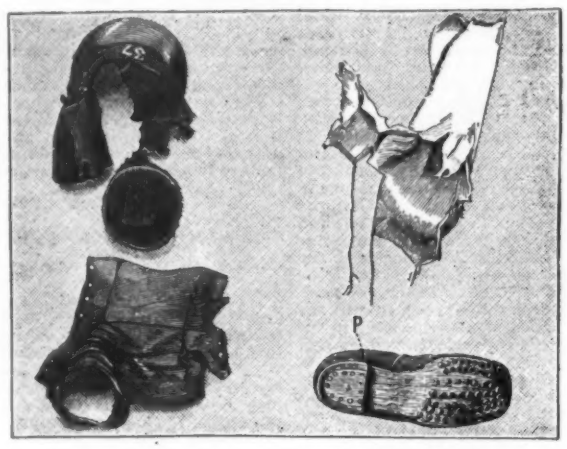


Fig. 2.—PORTIONS OF THE CLOTHING OF THE VICTIM STRUCK BY LIGHTNING—CAP, LOWER PART OF DRAWERS, GAITER, AND SHOE.

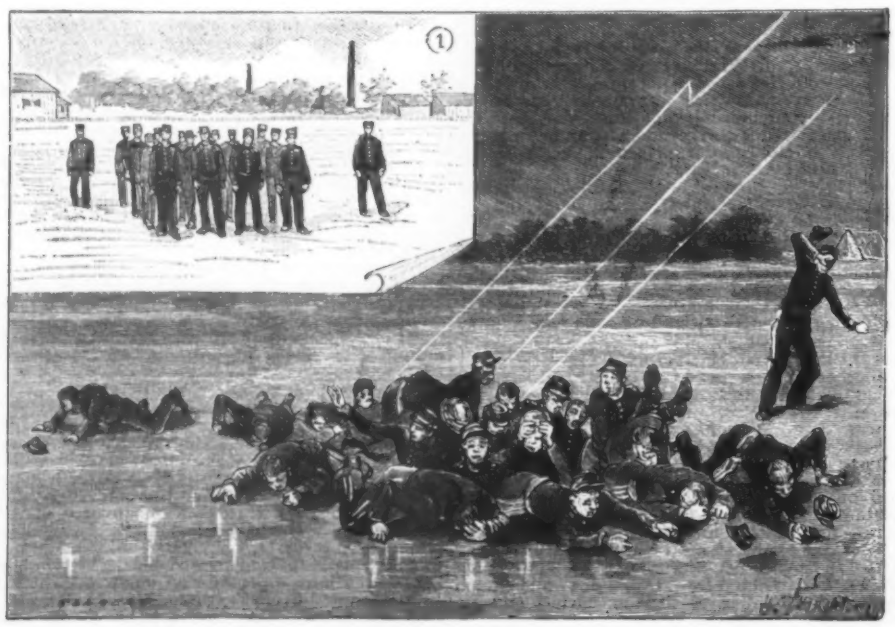


Fig. 1.—A FATAL STROKE OF LIGHTNING AT BOURGES.

1. Detachment of the 37th artillery before the catastrophe. 2. Men of the same detachment knocked down by the thunderbolt.

INSULATION.*

By Thomas A. Edison.

To telegraphy the insulation of the circuits is so vital a matter that at the risk of making history repeat itself, and of recounting an oft-told tale, a short paper on the subject may be tolerated.

As a class, gases are the best insulators; next liquids, and solids last of all. The insulation of gases is so good that no determination appears yet to have been made of any leakage through them. If it were possible to make an experiment at or near the center of the earth, so as to be beyond the reach of gravitational force, an electrified body might be left for hours in a gas without any visible means of support, and observations then made to determine whether any loss of charge took place through surrounding gases. Under existing circumstances, the loss of charge which always does take place on electrified bodies cannot readily be traced beyond that through the suspension or support that holds them. Even in moist air the loss of charge has not yet been brought home to the aqueous vapor. Prof. Boys exhibited before the Physical Society of London, in April, 1889, a pair of electrified gold leaves, suspended in moist air by a short hook of quartz. The loss of charge appeared to be about 25 per cent. in five hours. A glass hook, under the same conditions, would have allowed the charge to disappear, it was said, within one minute.

If any perfectly insulating solid could be found, telegraphists would soon discover any surface leakage from their wires through the air, for the surface of a No. 8 B. & S. wire is 224 square feet or 20·8 square meters per mile.

The loss of charge which takes place convectively into the air over any sharp point in an electrified body is a phenomenon of a different nature. There the layer of atmosphere over the point is continually being torn by the magnitude of the forces brought locally to bear upon it, and the particles of moving air carry away the charge.

Some liquids have also a very high insulation, notably most mineral oils. Animal and vegetable oils are by no means so good, or, at least, there is greater difficulty in obtaining them in a highly insulating condition. Water, contrary to prevailing notions, is quite an insulator. In the purest distilled water resistances as high as seven megohms per cubic centimeter have been recorded; that is to say, a block one centimeter cube of water pressed between two opposite conducting plates as electrodes would offer a resistance of seven megohms; but the least trace of impurity brings the resistance down.

Ice at —12° C. has been measured at 2,240 megohms per cubic centimeter. There are two conditions of surface upon which bare wires miles in length, laid on the ground, have been worked telegraphically—one over the dry desert sands of Africa, the other over dry ice in the far North. Sea water has a resistance of about 30 ohms per cubic centimeter at 5° C. It would appear probable that liquids cannot conduct without electrolytic decomposition. A microscope will show that one microampere decomposes the drop of water it traverses.

One of the most important and promising modern theories of chemistry is based upon the assumption, in accordance with a considerable array of facts, that solutions only conduct by the transfer of atoms or ions to the electrodes, each carrying an electric charge, and the conductivity of a liquid measures on this hypothesis the number of uncombined or dissociated ions permeating its mass. These free ions are the porters carrying the charge, and the conductivity of the liquid depends upon the number available and the speed with which they can migrate.

Liquids, too, have, as a class, the quality of elastic insulation to high tensions, which is an important feature to the electrical engineer. Air for the first few centimeters will break and allow a spark discharge to occur when the pressure reaches from 10,000 to 50,000 volts per centimeter (25,400 to 127,000 volts per inch), according to the shape and condition of the electrodes, but resin oil is said to stand about 75 times the pressure of air per centimeter without disrupting.

The following is a list of actually observed resistance in commercial samples of well-known insulating substances. The results are given in megohms per cubic centimeter at or near 18° C.:

Paraffine wax	110,000,000	megohms.
Heavy paraffine oil	8,000,000	"
Olive oil	1,000,000	"
Lard oil	350,000	"
Creosote	5·4	"
Stearic acid	350,000,000	"
Sperm oil	0·077	"
Benzine	14,400,000	"
Balsam copaiba	211,000	"
Benzole	1,320	"
Oil of wood tar	1,670,000,000	"
Crude ozokerite	440,000,000	"

All transparent solids are insulators, but of course the opposite statement is not true that all opaque solids are good conductors. There is now good evidence for believing that the process by which light is propagated, the mechanism by which it is transmitted

* A paper read before the Railway Telegraph Superintendents' Association, Denver, Colo., June 15 and 16.

through space, is purely electromagnetic, and the magnetic vibrations passing through a conductor would generate electric currents and be absorbed in the substance as heat, that is to say, it would be opaque to the light, failing to transmit the energy.

The difficulty with solids is not so much to find insulators, for the great majority of solid substances freed from moisture are poor conductors, but to find an insulation of suitable mechanical qualities. Glass, porcelain, and mica seem to be almost the only practically available insulators that will support considerable stresses, and these for many structural purposes are far weaker than is desired. In American telegraphy glass is almost the universal insulator, but in Europe, particularly in the south and west, the atmosphere is so much more humid and glass so hygroscopic that no circuit of any length could be operated with glass insulators except in dry weather. Porcelain or vitrified stoneware insulators are used instead, and in quite a variety of forms.

Practically speaking, the insulation of a line is never that of the material forming the insulators, but always that of their surfaces and the films of dust and moisture that may have become incrusted thereon. The most perfect insulators are those which have underneath the hood a cup filled with oil, in such a manner that the current leaking from the wire to the ground has to pass over the oil, or else through the substance of the insulator itself. These insulators are certainly more expensive, and require to be refilled with oil at intervals, but they will defy weather and keep the insulation nearly as high in fog as in sunshine.

When a long, leaky wire is opened at the distant end, and tested for insulation, the insulation per mile always appears to be somewhat more than it is for any actual mile, since the more distant portions of the line are tested with a reduced pressure, owing to the leakage over the nearer portion. When the wire is grounded at the far end, and its conductor resistance measured, the leakage will on the other hand make the apparent resistance per mile too low. But if the conductor resistance is reduced in a given ratio, say as 100 to 95, the insulation will be overindicated in the exact inverse ratio of 95 to 100, provided that the insulation of the line is uniform. So that if a wire's conductor resistance at its temperature of observation is known to be 10 ohms per mile, but appears by leakage over the whole length to be 9 ohms, then if the insulation per mile apparently measures 400,000 ohms, it will be really 360,000, and each mile taken separately might be expected to measure 360,000. As is well known, telegraph lines work better up to a certain point if the insulation is rather low. A wire has to be emptied of its charge between the impulses of the key sufficiently far to keep the relays from sticking. If the insulation is perfect this quantity has to be cleared through the ends to the ground, but if the line leaks it can escape more readily at all points.

The longer the line, the more essential good insulation necessarily becomes. The insulators are perhaps never more carefully tested than those intended for the long circuits on the Asiatic plains. It was at one time customary to test each insulator before it went out by taste. The insulator was immersed nearly to the rim head downward in the water, and a battery of 100 cells was connected with one pole to the water and the other to the insulator stalk through a particular kind of key. The operator first rested his moistened finger on this key and then applied his tongue to it. If he tasted no current the insulator was passed out as satisfactory. The test was sensitive and expeditious, and saved the care and handling of a galvanometer.

The insulation of a wire is a definite term and stands for a definite property so long as it is not necessary to measure it very accurately. There is usually no difficulty in finding the insulation of any overhead wire within 5 per cent. at any one time, and two observers measuring the line from the same end with different instruments would generally agree in their results to that limit; but as higher degrees of accuracy are attempted (a condition that fortunately does not practically occur), the difficulty of obtaining concordant results may increase rapidly. A resistance coil of wire at a uniform temperature can have its resistance measured to within one-fiftieth of one per cent. if necessary, but a leakage resistance is essentially liable to variation. The atmospheric conditions may be altering, or there may be polarization, or inductive disturbances from neighboring wires, or a combination of conditions that may set close measurement at defiance. It is generally advisable to employ galvanometers for this purpose, that, even if sensitive, are slow of movement and dead beat. The only instances in which accurate measurements of insulation are possible and necessary are in connection with subterranean or subaqueous wires. Jute and paper, dry or saturated with compound, are rapidly coming into use for subterranean wires sheathed in lead, while for long cables under water, India rubber and guttapercha are invariably employed. With conductors highly insulated by these methods, the insulation can be measured much more closely, and is definite for a given temperature of the core, but even in this case the current that will flow from a battery into the wire freed at the distant end is not all leakage. A considerable portion may be stored up in the insulating substance, and be returned from the wire to ground after the battery has been removed. This "polarization" is particularly noticeable with guttapercha and India rubber covered wires, and their insulation may be apparently 50 per cent. greater after three minutes of charging than at the end of the first minute. In specifications it is usual to call for a certain insulation per mile at 75° C. and after a definite interval of charge.

The insulation obtained from a given thickness of covering depends on the diameter of the wire as well as on the quality of the cover, for a large wire supplies a larger leaking surface. Also if an insulating coating of a certain thickness produces an insulation of 100 megohms per mile, doubling that thickness will not double the insulation, because the leakage will take place with greater relative facility through the greater surface of the second coat. The exact increase of insulation will depend upon the diameters of first coating and wire.

When a wire is well and homogeneously insulated, its insulation resistance at a given duration of charge or period of electrification will appear to be the same with different battery powers or voltages applied, but if, on the contrary, it contains any small faults or defects, it will generally show less insulation with increasing testing pressures. This often forms a criterion as to the reliable insulation of a long cable. The insulation in an ocean cable under the pressure of great depth, and near the temperature of melting ice that deep oceans approach, might be 15,000 megohms per nautical mile at the fifth minute. With a small incipient fault the insulation might still reach 3,000 megohms per mile and seem excellent, but it is probable that when tested with five cells and with fifty cells, the insulation resistance in the latter case would not appear so high. It would also probably be different with the zinc or copper pole to line.

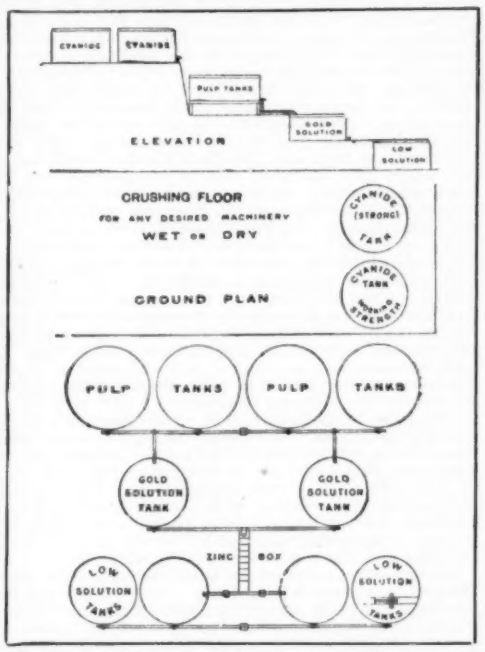
The only value that can attach to a high measured insulation is the assurance it conveys that no flaws exist in its covering or supports, and will therefore remain in good signaling order unless disturbed. In fact a very high insulation as we have seen actually tends to retard signaling. Mechanical security from the loss of insulation is the great desideratum rather than a very high degree of insulation itself.

[FROM THE MINING AND SCIENTIFIC PRESS.]

THE CYANIDE PROCESS FOR WORKING GOLD AND SILVER ORES WITHOUT AMALGAMATION.

THE MacArthur-Forrest process originated in England, and the English metallurgists have had longer experience in the promotion of the process in other fields of operation. The Gold and Silver Extraction Mining and Milling Co., of Denver, Colo., introduced the process in this country, and put up extensive works where practical working tests of ore are carried out.

The cyanide process is a system by which the ore, after being crushed by stamps or other appliances, is treated in tanks or vats with a solution of cyanide of potassium, by which the gold is dissolved. The solution carrying the gold obtained from the ore is then passed through boxes or filters containing zinc and the gold precipitated. The cyanide solution is then returned to a receptacle for repeated use.



CYANIDE PLANT IN SHASTA COUNTY, CAL.

This, in brief, is the process now attracting so much attention among mining men. The great value of the process lies in the fact that the sulphurets are treated without separation from the ore, at the same time, thus saving the usually subsequent operations of concentration, roasting, and chlorination. All that is required for a plant is the crushing appliances and suitable outfit of tanks, boxes, or tubs for the solution.

There are so many thousands of mines, the ores of which carry sulphurets which will not pay by the chlorination process, when all the other expenses are considered, that it did not take very long for the cyanide process to attract attention when once brought to public notice by practical tests on a good scale.

That cyanide of potassium would dissolve gold has long been very well known. In most standard chemistries, cyanide is mentioned for such a purpose, its properties are understood, and it is in daily use as a gold solvent in certain arts. But its practical applicability to metallurgical operations on a large scale has not been shown until very lately.

Whatever may be the merits of the controversy on the subject of patent rights in connection with this process or system, there is no doubt of one thing, which is that the MacArthur-Forrest patentees deserve the credit of first introducing and practically applying, on a large scale, the cyanide process for working ores.

The miners of this country, with sulphuret ores of low grade, have long been on the lookout for a method which would displace that of chlorination. Not but that chlorination returns a high percentage and is satisfactory from a metallurgical point of view. But it is too expensive for low-grade ores. This cyanide process can, under certain circumstances, displace it, and permit the working of ores of a lower grade than those adapted for chlorination.

The cyanide process is not a panacea, but works with certain classes of ores, and those classes of ores are the most abundant in this State and elsewhere. Where there are certain metals present it does not do well. But in most instances it appears to accomplish the object at a less cost than the processes previously in vogue.

The process has gone far beyond a laboratory experiment, and in one case, at least, works capable of treating 75,000 tons a year are in operation, which last year yielded from tailings nearly 20,000 ounces of gold. And this at a mine which is one of the best equipped for treating ore in the world. Any process which can show such a result would be worthy of investigation by miners elsewhere. But not only that, for there are other works in operation in different parts of the country nearer at home, the managers of which all speak favorably of the system as worked by them. Again, well-known metallurgists who have investigated the process indorse it for certain classes of ores, and these classes, as stated, are those which we have most abundantly.

Mr. A. B. Paul, general manager of the Calumet mine, writes of the process as follows:

It being generally known that the Calumet Co. was the first to introduce the MacArthur-Forrest process into California, on any practical working scale, my time has been considerably taxed in answering letters from very many mining men, not only in California, but elsewhere, all inquiring as to the practicability of the process, etc.

It may be information to many to state that in South Africa thirteen mills are now operating the process with great success, and that mills are already in operation in Colorado, Utah, Montana, Dakota, and California. At the Needles, in San Bernardino County, a 100 ton mill is in course of erection. Being among the first in this country to accept its merits, I fancy, by this time, I know something about it, and hence presume to speak.

The MacArthur-Forrest process is the use of a weak solution of cyanide of potassium. The strength of cyanide should be, as testing your ore will show, the proper per cent. for extracting the highest per cent. of the precious metals, say from one-half of one per cent. to one and one-half, then treating your ore for a given length of time with this solution. Time for treatment according to the character of your ore and metals, how much base and what kind. To get at this correctly, a few tests are necessary, but it is easily worked out. And here it is proper to state that time is more the factor of per cent. than a high per cent. of cyanide. You never want to use a high per cent., as this speedily attacks the base metals, while a lower per cent. attacks the gold and not the base, hence the lowest per cent. you can use to get the gold the better. We have many tests on this point, and all clearly establish this fact. I have failed in per cent. of extraction on some ore, and then by a few experiments gained high per cents. from same.

It is a process of study, but once you get time and per cent. determined, then there is no failure in your extraction from that especial ore, no matter to what extent you may go. So true has this been with our working, on a small and large scale, that taking any ore from any mine, I would not hesitate to build a 50 ton mill on a simple test of 50 pounds, if the per cent. of extraction was satisfactory.

There are two modes of having action from the cyanide on the ore—one is by agitation and the other is by time and percolation.

Agitation of ore in the solution more speedily dissolves the gold, at the same time it triturates the material, so as to make slums, and thus what is gained by agitation you lose when filtering the solution. Revolving barrels, or settlers, as used at times in silver mills, make good agitators. The percolating plan is the use of large tanks, whereby the ore rests in the solution, and in time is percolated off into reservoirs. Agitators take attention and power; percolation, less attention and no power, besides, agitated material must be discharged into filtering tanks and allowed time to draw off.

At Calumet, we first used agitators as per instructions, but after trying percolating gave it the preference, and are now pushing for enlarged capacity on this plan. This mode of working is being generally adopted in South Africa, presumedly by Mr. MacArthur's instructions. From my S. A. correspondent I learn that they are now constructing all mills for this way of operating the process. The new mill of the Shasta Co. is also changing to the percolating plan. The Mercer Mill, of Utah, was the first in this country to start on the percolating plan, on a scale of 30 tons per day, and made a big success from the very start. All percolated solution, whether from agitators or tanks, contains cyanide, gold and silver in solution; consequently, all vessels receiving the same should be perfectly tight, as you presumedly are handling valuable liquid, and for this reason iron tanks are to be preferred to wooden.

This percolated solution is now transferred to the precipitating box, of size according to the valuation of ore and quantity to be treated. The box used at Calumet is 14 feet long, with 14 apartments. These boxes have wire screens on the bottom, and are filled with zinc shavings four inches deep. The boxes are so constructed that the solution is made to pass through the body of shavings, which precipitates the gold and silver in a dark, blackish powder. By this part of the process a given part of the zinc is destroyed, but this is of no particular moment, as the loss is but trifling in dollars and cents. The Calumet Co. are soon going to change these wooden zinc boxes for white iron-stone chinaware, as made by the Toronto Pottery Works, Toronto, Ohio. Wood absorbs too much gold and cyanide.

The process is very simple and easily worked, when you have your plant right and start right on the per cent. of cyanide and time for your especial ore. It wants, however, to be handled intelligently, and it requires something more than mechanical skill to operate it properly. It is a process where brains and knowledge do not come in competition with "influence" or muscle. As to reducing ore, it is as yet an unsettled question whether it is best to crush wet or dry, all points being considered. The majority of the mills are crushing their ore dry. The Calumet Co. has started out a new lay, which I think will be the winning one; to wit, crushing by stamps and running the cyanide solution through the battery instead of water. In other words, crush your quartz in the solution, thus you combine agitation, percolation, and expedition.

This, though a new deal, suits us, and thus far no disadvantages present themselves that override the advantages gained. This plan has been in operation over four months, with no discouraging features, while

several additions have materially improved the plan. Of course you have to keep pumping your solution back and running round. For dry reduction the Shasta Co.'s mill uses pulverizing barrels. The advantage gained by the use of barrels is, all the ore is of equal grain, and as you do not require fine crushing for this process, by uniform gain of ore you do faster percolating.

Time, however, is the essence of per cent. more than fine crushing. As to the cost of working the process, there is a good deal to know before this question can be correctly answered; to give some idea, will say from $2 to $5 per ton. You can extract the gold and a high per cent. of silver from the great majority of ores. The question is as to time and at what per cent. of cyanide. There is a very erroneous idea as to the cost of cyanide, and it is well to now correct it. 98-99-100 per cent. cyanide costs in New York 50 cents per pound, f. o. b., as all can be assured by addressing the Roessler & Hasslacher Chemical Co., 73 Pine Street, New York.

As to silver extraction, at first I paid no attention to it, but have found the process very efficient, except requiring more time than gold; yet silver is in so many combinations that testing should be the only guide for any especial ore. It will work readily all ores worked by pan amalgamation. Taking California ores, from some it will often extract more silver than the total cost of milling. Yet it is not to be considered that every ore containing gold and silver can be profitably treated by this process. The most objectionable ones are those containing a goodly per cent. of copper. As to cost of plant, for gold it is very much cheaper than the ordinary first-class mill; for silver, the expense will not be half the cost of pan mills.

To express myself as to the process will be to declare it one of the wonders of the times. I am aware that it has not the friendship of some men of science, who talk wisely on what they do not know. To me all opposition is as a puff of wind in the face of every-day demonstrated facts as I handle the process. I have been cursed too often by disappointments in yields, by our old systems, to not appreciate the fact of always being sure of a high per cent. of the value of the ore I treat.

One of the astonishing features of the process is that you can take the heaviest sulphureted ores, and, without roasting, extract 95 per cent. of the value out of the same, and then you cannot detect any perceptible difference in their appearance. This was the hardest part for me to realize, but I have long ago got over the doubt, but not the wonder.

One of the inviting features of the process is that all the machinery you want is for reducing your ore, and power to drive it; and what a comfort there is in this every mill man can realize. Then, coupled with the fact that your returns are certain, a wise man can grasp the future of mining. Thus I give the reader some idea of what the process is. Of course there is more or less detail, which can only be gained by practical manipulation of it.

Mr. C. H. Aaron writes as follows:

In the earlier working of this process the finely powdered ore was agitated with the cyanide solution in revolving barrels, or in pans, and, after a certain number of hours, was passed to a filter vat, drained and washed. This plan is generally giving place to simple percolation in filter vats which are made of sheet iron or steel in some of the mills.

It is one of the advantages of the process that it admits of the use of iron vats, tanks, pipes, pumps, etc., but brass must be avoided. The iron vessels should be coated with a mixture of coal tar and asphalt, put on as hot as may be, not because the chemicals act directly on iron, but because the iron will otherwise rust rapidly.

There seems to be no reason why wooden vats and tanks should not be used, as, in fact, they are in some mills; they also should receive a coat of tar and asphalt, inside at least, to prevent excessive absorption of the solution, or I think paraffin, well soaked into the wood by means of heat, would be as much superior to tar in effect as it certainly would in appearance, but it should be tested first to ascertain if it will permanently resist the solution, which no ordinary paint, white lead, or lac varnish will.

An improvement introduced as to this process by Mr. A. B. Paul, though long in use in silver lixiviation, is the discharge of the vats by sluicing the sand out through a gate to a launder, in which a stream of water flows. Mr. Paul's gate is very simple, consisting of a cast iron frame, with suitable lugs for securing the closure, bolted to the side of the iron vat, from which a corresponding piece has been cut out. The closure is simply a piece of pine board with a gasket of blanket on the seat. The filters are like those used in the chlorination process, or in lixiviation of silver ores, burlap on a perforated false bottom or a grating. The lixivium flows out from below the filter through an iron faucet, for which I think I should substitute a small nipple with a piece of soft rubber hose attached into a launder, and so to a sump, whence it is drawn as required by an iron pipe to the precipitating boxes. The launders are sometimes made of boards and nailed together, which is bad; they should be of sheet iron, tarred, or of wood pipe ripped in two and tarred inside; also they should be covered to exclude dust, etc. So far as the process is understood as yet, it would seem desirable to avoid unnecessary exposure of the solution to the air by allowing it to drip or flow from a height carrying air with it, into the liquid already in the receiving vessel, or to fall with a splash into launder, etc. Another good point in the process is that very coarse crushing answers for many ores, the extra time occupied by the extraction being fully compensated by the economy in crushing, and the saving of time in the draining and washing, owing to more rapid percolation. At the Calumet mill they crush wet through a 30-mesh screen, whereas much higher numbers were necessary for amalgamation; this, however, depends on the structure of the ore. If the metal to be extracted is diffused in grains through a compact gangue, fine crushing is a necessity; but if it is in streaks, veinlets or seams, or if the gangue is very porous, coarse crushing even to the size of a pea may suffice.

When very fine crushing is required by the nature of the ore, it may be best to use the method of agitation in barrels, etc., but then the filter press should be employed to separate the liquid well and quickly from the pulp. In default of the filter press, filter vats and suction, either by fall or by pumping, may be resorted to. With ores which yield much slime, the coarser portion, or sand, may be separated and treated by percolation, and the slimes by agitation and the filter press.

The extraction of coarse gold by this process is not feasible. Where such gold occurs in conjunction with fine gold or auriferous sulphurets, I think it would answer to crush wet and amalgamate in the battery, passing the tailings into the percolators, which must be provided with overflow pipes or launders to conduct the excess of water to a sump, whence it may be returned to the battery. If the ore is such as to require a preliminary treatment with lime or caustic soda, etc., these may well be put into the battery with the ore. Where such treatment is not required the cyanide may be put into the battery as is done at the Calumet mill; this may, however, slightly increase the deterioration of the cyanide by atmospheric action.

I believe Mr. A. B. Paul originated the method of putting the cyanide into the water used in the battery. He also added lime, but has given that up. I doubt if his ore requires lime or alkali, but I shall recur to the matter in the course of this article.

As to the means of crushing, it is with this as with all lixiviating or leaching processes, the more equal in size the particles are, the better, hence those machines which give the best result in this respect are, other things being equal, the best for the purpose. Dry crushing stamp batteries are notoriously defective in this regard, though there is an arrangement which I have described before, and which I cannot take time to describe here, by which the defect may be in a measure obviated. I think, however, that wet crushing will be generally adopted, as it has much in its favor, and not a particle of ore need be lost where it is used. Where the quantity of slimes is not large, such portions as may still settle in the sump may be transferred periodically to a special vat and treated at leisure.

It is not necessary to separate the sulphurets for special treatment; hence, in a case like that at Calumet, the manipulation is extremely simple. It is only necessary to crush the ore suitably, flow it into filter vats, allow the liquid to percolate for a sufficient length of time, and finally sluice the ore out of the vats. What though it may require four or six days to treat a charge? Vats can be made to contain 100 tons of ore and solution. At the works of the Robinson Gold Mining Co., Limited, in South Africa, they have recently increased their plant by the addition of twelve vats of 2,000 cubic feet capacity each for the treatment of tailings. A set of vats properly cared for will last a lifetime, consuming nothing more than an occasional coat of tar. And there need be no hurry nor worry; if a workman or two should leave unexpectedly, the work will not be at a standstill, for almost anything in the shape of a man, or even a woman, can do the work under proper direction, so little is skilled labor required. It is the most comfortable process to conduct that I know of, but a good assayer is required, and if he is also a fair chemist, so much the better.

The precipitating box is a wooden trough about a foot wide and deep, closed at the ends and furnished with a cover. The length is, at Calumet, from 12 to 16 feet, divided into about a dozen compartments by partitions which alternately extend to within an inch of the bottom and within several inches of the top. In each compartment is a tray or box with sides of wood, the lower edges furnished with sheet rubber gaskets tacked on; the bottom is a seive of iron wire with 8 or 10 meshes to the linear inch. The upper part of the box fits snugly in the compartment, the sides being drawn in or tapered toward the bottom to facilitate removal by means of a bar of wood fixed across the top as a handle. The lower edge rests on a ledge or rabbet, and by means of the rubber gasket makes a tolerably close joint. The solution passes alternately upward and downward through the sieves or trays, flowing over and under the respective partitions.

Zinc shavings are placed in the sieves and upon them the precious metal is deposited. At suitable times the trays are removed, one by one, and shaken in a pan of water, when the precious metal, in the form of a black powder, together with particles and shreds of zinc, passes through the sieve. The tray is replenished with zinc shavings from another tray nearer the tail end of the trough, and replaced. Fresh zinc is charged into the last trays of the series, of which the contents have been transferred to the preceding trays. The reason for this is that the gold, etc., is deposited more rapidly on zinc that is already coated with gold than on clean zinc. The mixed gold, silver, and zinc in the pan is then sifted by a wire sieve of sixty meshes to the linear inch to separate the coarser particles of zinc, these being placed on top of the shavings in the first tray. The precious metal is then washed, dried, and melted in sandpots, with fluxes adapted to slagging off zinc, copper, if present, and other impurities. The liquid leaving the box retains a little dissolved gold, which is not lost, because the liquid is used again.

At Calumet the precipitating boxes are of naked lumber. I should think they would be better if well paraffined, or, perhaps, black varnish might answer. Mr. Paul is going to have trays of porcelain, the advantage of which is not obvious to me. The entire apparatus might be of iron.

The zinc shavings are made at the Calumet mill from the cases in which the potassium cyanide is received, which are made of sheet zinc. The sheets are cut into disks of about six inches diameter, each with a hole in the center of about three-fourths inch diameter. The disks, to a number sufficient to make a cylinder or cheese about four inches thick, are placed on the iron spindle of a simple lathe driven by a belt, and are held firmly by being compressed between two disks of iron. As the spindle revolves, a cutter, just wide enough to take all the zinc disks while clearing the iron, is pressed against the cheese and takes off a thin shaving which consists of as many strips as there are sheets of zinc in the machine.

A statement which has excited some surprise is that a sample taken from the upper stratum of the charge of ore in a vat, at any time during the progress of the lixiviation, correctly represents the entire charge as to its assay value. I think this is explained by the fact that the precious metal dissolves so slowly that the percolating liquid is never even approximately saturated; thus the action is practically equal throughout the mass, and there is at no time an appreciable difference between the upper and lower portions.

At Calumet, the lixivium is circulated; that is, the liquid which is passed through a charged vat is not passed at once to the precipitation, but pumped up and returned to the vat, being at the same time reinforced by an addition of cyanide, so that it contains 0·00 per cent., the original strength having been 0·50 per cent, as it went to the battery. Not solid cyanide, but strong solution from a special vat, is used for the reinforcement. When the assay of a sample of the pulp shows a sufficiently close extraction, the liquid is allowed to subside to the surface of the ore, and is followed by a sufficient quantity of water, which is allowed to drain out and pass to the stock solution, compensating loss by evaporation, etc. I regret that I cannot at present give statistics as to cost of treatment and percentage of extraction. As I do not care to offer these at second hand, I must refer the reader to those who know all about them.

I now approach a difficult part of my subject. The cyanides have not received so much attention from chemists as have many other compounds; with special reference to the treatment of ores they have scarcely received any, hence the chemistry of the process is not very well understood by metallurgists; at least, very little that is of value can be found on this subject in the standard works. What I say must therefore be understood to be, to a great extent, only my present opinion, subject to correction as experience may afford more light, or as those who know more about the matter may come to the front. I will remark, however, that the subject is complex, and the chief use of theoretical considerations must, for a time, be to suggest, guide, and to some extent limit experiment, which is the court of last resort.

It is an old story that solutions of certain cyanides can dissolve not only many metal compounds, such as silver oxide, chloride, etc., but also several of the metals themselves, in the metallic state, notably silver and gold. Attempts have been made, from time to time, to apply the cyanide solutions to the lixiviation of ores, but with little success unless recently. The keynote of the present process is the fact that extremely weak solutions, acting through considerable periods of time, give the most satisfactory results. The precipitation of gold and silver from the cyanides by means of zinc has long been used by photographers; it is in the specially advantageous form in which the zinc is applied that an advance has been made in this direction. Some attempts have been made at Denver to apply electrolysis to the recovery of the gold and silver extracted from the ore, and, although these attempts did not succeed, I think electrolysis will finally be adopted.

There seems to be a difference of opinion as to the chemical reaction by which metallic gold and silver are dissolved, some saying that access of air is essential, while others deny that. I have not yet had an opportunity to investigate this, which, however, I think would not be very difficult, because if pure potassium cyanide in pure water can dissolve a metal, it would seem that hydrogen must be evolved and potassium hydroxide formed. Mr. Louis Janin, in an article published in the *Engineering and Mining Journal* of December 29, 1888, on *Cyanide of Potassium as a Lixiviating Agent for Silver Ores and Minerals*, expressed the belief that hydrogen was evolved from the surface of a piece of silver exposed to the action of a cyanide solution. The action is so very slow that it will require some time and patience to settle the question, which may have a practical bearing.

There is also a want of agreement as to whether the gold in ores is ever in other than the metallic state, though it is generally conceded that true tellurides of gold exist. Mr. Henry G. Hanks, however, has expressed the opinion, based on experiment, that the gold in the so-called tellurides is really metallic.

Be this as it may, the process seems to be able to extract the greater part of the gold from many ores, also the silver, though not so well, usually. By the use of weak solutions the extraction of base metals is reduced to a minimum; yet, as the copper sulphide is soluble in a solution of potassium cyanide, it results that some ores yield a portion of copper which is precipitated with the precious metals on the zinc. It is said that copper oxide also dissolves.

Ores which contain, or have contained, sulphurets which have become partly or wholly oxidized usually receive a preparatory treatment, the object of which is the decomposition of various metal salts, the neutralization of acid or removal of certain oxides, as those of lead or zinc, which would otherwise decompose the cyanide solution or obstruct its action. This consists in subjecting the pulp to the action of lime water, or of a solution of caustic alkali, by means of percolation, etc. In some cases carbonated alkali, as lye of wood ashes, would probably serve the purpose, though I have not yet heard of that being tried. The preparatory treatment sometimes occupies thirty-six hours or more, and in some instances costs more than the extraction. A private letter from Africa says that three months of experimenting were necessary in one mill to find a suitable method of preparing the material—tailings—for the extraction; unfortunately the cause of the difficulty, and the remedy, were not stated. "Practical men" may be interested in knowing that it was a chemist who finally solved the problem. I suspect that some cases may require acid instead of alkaline washing, or perhaps acid first and alkaline following.

A disadvantage of lime water is the extremely slight solubility of lime; this might perhaps be remedied by mixing lime with the ore, either in wet or dry crushing, in more than sufficient quantity to saturate the water, then as fast as the dissolved lime should do its work a fresh quantity would dissolve, and so on; but if this were done, either the excess of lime must be completely washed out, or results will follow on the application of the cyanide which will be considered shortly. Hot lime water has been tried, but did not answer so well as cold; probably the advantage of heat was counterbalanced by the diminished solubility of lime in hot water. As the presence of common salt increases the solubility of lime, I suggest a trial of it.

It has often been suggested that the caustic alkaline and cyanide solutions might be applied simultaneously, that is, the lime or caustic alkali might be added to the cyanide. This may answer in some cases and not in others, depending on whether the cyanide or the alkali, etc., would act most promptly on the deleterious substances. If base metal cyanides should

be formed, which the alkali would not decompose, a loss of available cyanogen would result, and this loss would be greater in the case of the soluble metal cyanides, such as those of zinc or copper, than with the insoluble ones, because a metal which forms a soluble compound not only decomposes an equivalent of potassium cyanide, but also combines with another equivalent, withdrawing that also from the field of utility. As to iron, it appears from the article by Mr. C. W. Merrill, republished in the *Press* of April 25 last, that ferrous cyanide is decomposed by caustic alkali, which means that the useful alkali cyanide is regenerated in that instance.

I have mentioned that in the Calumet mill the cyanide is used in the wet crushing of the ore; until recently lime was also added, in pursuance of the idea of dispensing with a separate preparatory treatment. That the extraction was satisfactory does not prove that the principle is correct; it must first be shown that the ore needed such treatment, which I doubt.

But, granting that the ore did require something of the kind, let us see what would be the effects of putting lime into the battery with the cyanide solution. In the first place, it is very doubtful if the lime could perform its function instantaneously, except as to soluble sulphates of copper and iron, not as to insoluble basic salts which would be likely to exist and would yield but slowly to the action. Also, it will be readily admitted by chemists that the quantity of the lime could not be accurately adjusted to the requirement Hence an excess must be used; in fact, five pounds of lime were added for each ton of ore.

Commercial cyanide contains a quantity of alkali carbonate, which caustic lime changes to caustic alkali with simultaneous production of insoluble calcium carbonate; so far then, we find we have caustic alkali to complete the work for which the lime was used, and it would be much the more efficacious, at least as to some substances. But the lime is added continually with the ore, while the sodium carbonate is only added at long intervals in the added cyanide. Hence the lime is almost sure to be in excess of the sodium carbonate, at least temporarily, perhaps permanently. In working ten tons of ore per day, 50 lb. of crude lime, equal probably to at least 35 lb. of pure lime, were used; in the same length of time, 18·6 lb. of cyanide of 70 per cent. purity were used, which could not possibly have contained more than 5·58 lb. of sodium carbonate, and certainly did contain less, because of other impurities; say it contained 4 lb.; this would leave the lime largely in excess permanently. The next effect of the excess of lime would be to decompose potassium cyanide, forming calcium cyanide, which may be just as good, and caustic potash. Thus we see that lime produces caustic alkali in the solution. What may be the effects of that?

At the Calumet mill, the results are not known to have been deleterious, and on the other hand, the abandonment of the use of lime had not, at last accounts, produced any bad effect, but the inventors of the process have cautioned operators against the presence of caustic in the cyanide, claiming that it does harm. With ores like those of the Comstock, containing sulphantimonides, caustic alkali produces alkali sulphide, and it has been stated by some that alkali sulphide interferes with the precipitation of the gold. Caustic alkali will also dissolve the oxides and sulphates of lead if present, and many other substances the effects of which on this process I do not know. Thus, those who are waiting for Mr. Paul's results, in order to follow his example, should remember that what may suit his case may not suit theirs. One effect of caustic alkali must be to increase the consumption of zinc.

In whatever form the lime may exist in the solution, except a trifling quantity of sulphate, it will constantly fall out, wherever the liquid may flow or remain, as calcium carbonate, causing some inconvenience; and unless there is some special advantage in the use of lime it would seem better to use caustic alkali. This, it must be understood, applies only to the use of the lime in conjunction with the cyanide, as was done at Calumet; it has no bearing on the use of lime water in preparatory treatment if the ore is washed before applying the cyanide.

I will now show how the presence of caustic alkali, whether produced by means of lime or added as such, may be beneficial; also that it is probably impossible to work the process without producing at least a small quantity of caustic.

Carbon dioxide (carbonic acid gas) is always present in the atmosphere, and it has the property of displacing cyanogen from the alkali and alkaline earth cyanides, forming prussic acid, which gradually evaporates. This causes the odor of potassium cyanide. But if caustic alkali is present, it takes the carbon dioxide and is converted into alkali carbonate, prussic acid is not formed, and cyanogen is not lost; or, at least, if prussic acid is formed, it is instantly neutralized by the caustic alkali, and an alkali cyanide is reproduced. These reactions may be thus expressed:

$$2\,K\,C\,N + C\,O_2 + H_2\,O = K_2\,C\,O_2 + 2\,H\,C\,N, \text{ and}$$
$$2\,H\,C\,N + 2\,K\,O\,H = 2\,K\,C\,N + 2\,H_2\,O.$$

If calcium is present as lime dissolved in the liquid, it will combine with the $C\,O_2$, whether caustic alkali is also present or not, forming insoluble calcium carbonate; and if it is in the form of calcium cyanide, resulting from the action of lime, as before explained, it will still combine with $C\,O_2$, with or without evolution of $H\,C\,N$ and consequent loss of $C_2\,N_2$, according to whether caustic alkali is present or not. Thus we see that caustic lime or caustic alkali in the liquid protects the cyanide from the decomposing action of atmospheric $C\,O_2$. As to caustic lime, however, that cannot probably be present until all the potassium cyanide has been decomposed while an excess of lime remains.

I have said it is probably impossible to work without the production of caustic. Whether or not the gold in dissolving produces caustic, as I think it must, it is a fact that hydrogen is evolved in the precipitation box, and that means that zinc dissolves, forming zinc cyanide and caustic potash (or lime, as the case may be; the lime would make caustic soda as soon as it should come in contact with sodium carbonate, from the impure cyanide added daily). I do not think that pure zinc can decompose pure potassium cyanide in solution, at least not rapidly, until some caustic has been formed, but as soon as iron or gold is placed in contact with zinc in a cyanide solution, pure or not, a brisk evolution of hydrogen begins, and every chemist knows what that must imply. In the precipitating box the zinc is in contact with both gold and iron, the gold which is precipitated on it, and the iron sieve on which it rests. I saw the mass of zinc shavings actually lifted to the surface of the liquid by the floating effect of the hydrogen.

There are some interesting facts connected with the precipitation of metals from the cyanide solution. I examined some of the precipitate from the mill, which consisted of gold, silver, copper, calcium carbonate and other substances, including fine shreds of zinc. To my surprise the copper dissolved with effervescence in dilute hydrochloric acid, which proved that it was not in the metallic state; it also dissolved, at least partially, in dilute sulphuric acid. The gas evolved was without distinctive odor, and the solution by hydrochloric acid contained cuprous chloride, as shown by the formation of oxychloride in the neck of the funnel and on the surface of the liquid. I did not remain at the works long enough to investigate this matter, but Mr. T. E. Eichbaum, the chemist there, has since verified the facts and made further observations, not only in this regard, but also as to the precipitation of the precious metals.

Another circumstance which I observed, and which Mr. Eichbaum has also verified, is that zinc does not precipitate copper from a solution made with potassium cyanide of 98-99 per cent. purity, nor does it cause evolution of gas. On adding metallic iron, in contact with the zinc, a brisk evolution of gas takes place, yet copper is not deposited. If, however, the solution of copper is made with the impure cyanide used in the mill, copper soon makes its appearance on the zinc. The latter fact is reported by Mr. Eichbaum, and I am not sure whether or not he found an addition of caustic necessary to the effect, which is important, because, though the mill cyanide certainly contains carbonate, it does not seem to contain caustic.

The lixiviating solution is assayed daily for available cyanogen as represented by percentage of pure potassium cyanide. This is done by means of a standard solution of neutral silver nitrate which is delivered, by means of a burette, into a measured quantity of the liquid to be tested. As soon as turbidity ensues in the liquid, the burette is read, and a simple calculation shows the percentage strength in potassium cyanide, or its equivalent in sodium or calcium cyanide. Metal cyanides, or metal and potassium, etc., double cyanides which may be present, do not interfere; hence the process does not show the entire quantity of cyanogen present, but only that which is in a useful condition, which is what the operator desires to know.

The *rationale* of the assay is that while silver cyanide is insoluble in water, and in solutions of such substances as may be present in the liquid, other than free cyanide of potassium (solution or calcium), yet it is soluble in that, hence cannot form a precipitate until that is all disposed of; the quantity of silver nitrate consumed before a precipitate appears is, therefore, the measure of the available cyanide present. The necessary reinforcement is made by adding a measured quantity of concentrated solution of cyanide, of known strength, to a known quantity of the stock solution in a tank.

What becomes of the zinc which continually goes into the solution? This question is often asked. I have a certain suspicion on this point, but for the present will only say that the zinc does not appear to have caused any inconvenience thus far, though the solution has been used constantly for many months, it is said for a year, without other renewal than the daily addition of cyanide and water to make up for loss. Owing to this addition of water, the stock solution can never become saturated with zinc, the accumulation of which cannot pass a certain maximum; the same is true of the alkali carbonate which, in the absence of lime, must be constantly forming.

The effects of these substances, as well as of others which may be in the crude cyanide used, and of yet others which may be added if desirable, will form an interesting study which may lead to a means of increasing the efficiency of the process, especially in the extraction of silver. There is also room for improvement in the form of precipitation of the precious metals, and for the exclusion of base metals and other impurities by which they are often contaminated.

It is said that zinc and copper may be removed from the solution, and alkali cyanide regenerated, by means of an alkali sulphide; this has been doubted, at least as to copper, because of the solubility of copper sulphide in solution of alkali cyanide. It may be that in the weak solution used, the copper sulphide may form and may endure long enough to enable its removal.

I must say I expect to hear of many disappointments as to this process, though but little harm need result if those who may think of adopting it will first have it thoroughly tested with regard to their particular ore. It should not be supposed that all ores of precious metal can be treated successfully in this way, nor that it will have the advantage of relative economy in all cases. There are instances in which gold quartz is mined and milled profitably on a yield of $3 per ton or even less, the cost of milling being often as low as forty cents per ton; the lowest estimate I have seen of the cost of this process is $1.50 per ton, under favorable conditions, clearly then it must save at least $1.10 per ton more in such a case than common milling, or there must be a relative loss. It is of no use for enthusiasts to exclaim and protest that it will do this and more; it must be proved by trial in each particular case, at least until we shall know more about the subject than we do now.

Nevertheless, I think there is a wide field of usefulness for the process, even now, in the treatment of material, whether original ore, tailings, slimes, or concentrates, in which the gold exists in very fine particles. Some assert and others deny that the so-called tellurides yield to the process, and I have not heard of a satisfactory result from ores of which a large part of the value was silver, excepting some of Mr. Janin's results as reported by him in the article referred to above, and lately as to Comstock ores which have never been considered as refractory, and from their composition would seem likely to yield to this process.

This article is not written in the interest of Messrs. MacArthur & Forrest, nor in that of any of their representatives, but in response to a general demand for information and opinions in regard to the treatment of ores by means of cyanide solutions, regardless of the claims of the alleged inventors or patentees, with which I do not occupy myself. Personally, I should prefer to see the metallurgical field untrammeled by patents—unless I could get a good patent myself—though if this process had not been patented, many who may use it would never have heard of it. Moreover, people are very apt to think that information or advice which costs nothing is worth just its price, that is nothing, and to disregard it accordingly, as I have had frequent occasion to observe.

Note.—In considering the effects of lime, I overlooked the circumstance that sodium carbonate and potassium cyanide in solution together will, wholly or partially, exchange constituents, which, however, will not alter the ultimate effects.

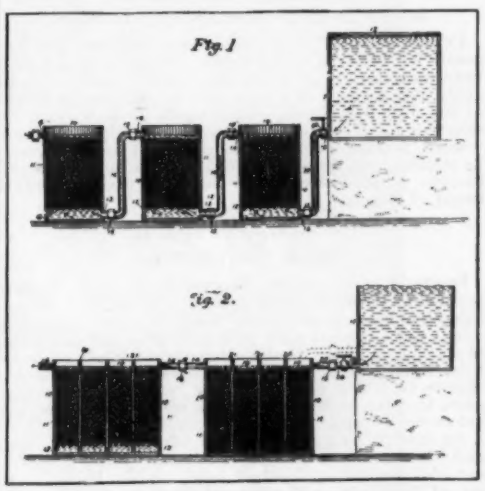
It seems probable that there may be a formation of ammonium cyanide in the solution. Atmospheric oxygen absorbed by the solution produces, I think, not a cyanate, as suggested by Mr. MacArthur, but potassium carbonate and ammonium carbonate; the latter probably transfers carbon dioxide to the alkali of the cyanide and forms ammonium cyanide.

So long as an ammonium salt is present, the electrochemical action in the precipitating box must produce, not caustic alkali, but caustic ammonia, a part of which must escape, entrained by the hydrogen, while another part takes up atmospheric CO_2, probably transferring that to the alkali of a portion of the alkali cyanide, and returning to the state of ammonium cyanide; thus the latter salt may gradually accumulate in the stock solution.

I have made some experiments on a sample of auriferous pyrites which yield nearly all of the gold to seven hours treatment with a one per cent. solution of potassium cyanide. My results indicate that the cyanides of potassium, sodium, and ammonium are equally efficient, molecule for molecule, and that, with such an ore at least, the presence of an alkali chloride has no marked influence.

THE MacARTHUR METALLURGICAL FILTER.

THE metallurgical filter, patented by John S. MacArthur in this country Dec. 24, 1889, is intended for precipitating and separating precious metals from solutions containing them, such, for instance, as chlorides, bromides, thiosulphates (sometimes called "hyposulphites"), or sulphates obtained in the well-known



MacARTHUR'S FILTER, WITH ZINC SPONGE.

Plattner, Von Patera, Russell, Ziervogel and Augustine extracting processes.

The object of the invention is to provide a filter having a large active surface for the metals in solution.

In the accompanying drawings, Fig. 1 is a sectional elevation of a series of these improved filters. Fig. 2 is a longitudinal vertical section of a filtering apparatus comprising two of these improved filters constructed in modified form. The zinc filiform sponge constitutes the principal feature of this improved filter.

Similar numerals of reference indicate corresponding parts in the different figures. This improved filter comprises a containing vessel, 10, and a zinc sponge, 11, disposed therein. The zinc sponge is preferably supported on a perforated false bottom, 12, disposed within said vessel near the bottom proper thereof. The vessel is provided with an inlet tube, 13, and an outlet tube, 14, the inlet tube being preferably disposed near the bottom of the vessel and the outlet tube near the top thereof, each of said tubes being provided with a coupling nut, 15, when the vessels are used in series.

A number of these filters is preferably arranged in series, as represented in Fig. 1, from six to ten being ordinarily employed. When so arranged the filters are connected by pipes, 16, which extend from the outlet near the top of one vessel to the inlet near the bottom of the adjacent vessel. A reservoir or tank, 17, for containing the solution holding the precious metals, is disposed adjacent to the first filter of the series and elevated a sufficient distance to secure a proper flow of the liquid through the filters. This tank is provided with an outlet tube, 18, near its bottom, said tube being provided with a stopcock, 19, and connected by pipe, 20, with the inlet tube of the first filter of the series.

The zinc sponge, which constitutes the filtering material and precipitant, is preferably composed of fine threads or filaments of zinc interlocked together. The zinc threads from which the sponge is formed are cut by a turning tool from a series of zinc disks held between lathe centers and turned; or the zinc sponge may be formed by passing molten zinc, at a temperature just above the melting point, through a fine sieve and allowing it to fall into water. This improved zinc sponge presents a very large contact surface for the

action of the solution, and it does not become easily choked.

Each containing vessel may be provided with a vertical partition or partitions, 21, as illustrated in Fig. 2, whereby the vessel is divided into two or more compartments or filtering chambers. These partitions extend to a point near the bottom or top of the vessel, as the case may be, or they are provided with holes near the top or near the bottom of the vessel. In case the vessel has three or more filtering chambers, the partitions are provided with communicating openings, disposed alternately near the bottom and top of the vessel, whereby the passage of the solution is downward through one of the filtering chambers, upward through the adjoining filtering chamber and downward again through the third filtering chamber, and so on.

In the use of this improved filtering apparatus the solution containing the precious metal is placed in tank, 17, and the cock, 19, is opened. In case a series of separate filters is employed, as represented in Fig. 1, the solution passes from the tank through the pipe, 20, and into the first filter of the series, near the bottom thereof, beneath the false bottom, 12, thence upward through the zinc sponge within the filter, thence outward near the top of the first filter, thence through the connecting pipe to the next filter of the series, where it again enters near the bottom and passes upward through the zinc sponge to the top of the second filter of the series, and so on. The metal which is not precipitated by the first filter is caught in the zinc sponge of the succeeding filters of the series.

In case filters having a number of compartments are employed, the solution is preferably admitted to the first compartment at the top thereof, and passes down through the zinc sponge contained in said compartment to near the bottom thereof, and thence passes into the second compartment and upward through the zinc sponge therein contained, to near the top of said compartment, and thence downward through the next compartment, and so on through the several compartments of the compound filter, and thence to the next compound filter of the series, and through its several compartments. The precious metal may be separated from the zinc sponge by distillation, or the zinc sponge containing the precious metal may be placed in a suitable sieve and subjected to a screening operation, preferably under water. In this operation the greater part of the precious metal will pass through the sieve, and the greater part of the zinc sponge will remain therein.—*Mining and Scientific Press.*

LONG-TAILED JAPANESE FOWLS.

IN his book, "Darwin, and After Darwin," Dr. Romanes has collated an immense number of facts which bear upon the theory of Darwin, and he illustrates them aptly both in word and by woodcut—witness the figure of the Japanese fowls, which teach us how man, by selecting for breeding purposes birds with a tendency toward feather profusion in a special direction, and by weeding out those which did not exhibit this special feature, at last succeeds in evolving the long-tailed breed of Japan.

[FOR THE SCIENTIFIC AMERICAN.]

RAT CATCHING.

IT would seem almost impossible to create a new profession or to discover a new occupation. Everything has been so frequently tried, so many ingenious minds have applied their wits to finding out new ways of making a living, that to the myriad kinds of business thus established it might seem there was no chance to add a new one. The book before us suggests that at least all branches of usefulness are not yet overcrowded.

An entertaining account of his efforts at rat catching and his success in making a life-supporting industry out of it has been published lately by Mr. H. C. Barkley, of England. Although rat catching has almost a legendary antiquity since the days of the Pied Piper of Hamelin, when

> "Great rats, small rats, lean rats, brawny rats,
> Brown rats, black rats, gray rats, tawny rats,
> Grave old plodders, gay young friskers,
> Fathers, mothers, uncles, cousins,
> Cocking tails and pricking whiskers;
> Families by tens and dozens,
> Brothers, sisters, husbands, wives—
> Followed the Piper for their lives;"

yet it strikes one that the field perhaps merits the distinction of being almost untrodden, and that many vigorous and roving natures might find in it a congenial and lucrative employment.

Mr. Barkley describes the most necessary accessories of his trade, in three terms, pluck, good ferrets, and good dogs. As he supplied the first element of success he has little information or suggestion to offer on that head, as he assumes that the individual who in other respects follows his advice will bring of necessity the supply of energy desired to make either the ferrets or the dogs useful. The ferrets are the *sine qua non*, however, of the rat catcher's outfit, and too much attention apparently cannot be given to their careful selection and proper care.

In the first place there are two kinds of ferrets as respects color, the dark brown and tan and the albino varieties, white with pink eyes, and one, according to Mr. Barkley, is as good as the other for work, though Mr. Barkley himself preferred the white, as it is sooner seen when emerging from a hole. Much of Mr. Barkley's work was done in the farming districts of England; and along fences and ditch bottoms a white ferret was more quickly recognized. There is, he says, a cross between them which is less serviceable than either, being bigger and in his opinion slower and less daring. For rat catching the female ferret is used, as she is not so long as the male and can therefore penetrate more inaccessible retreats of the rats and follow them through narrower holes.

Young ferrets are esteemed braver than the older animals, having more vitality and eagerness in their chase after game, and as Mr. Barkley remarks, have no bitter experiences to remember which might tend to qualify their courage. Above all do not expect to implant the instinct of daring in a ferret. If the animal proves incapable and timorous, discard it at once. In buying brown ferrets take the darker colored ones and in female ferrets choose the long ones, as size and strength has a better chance with big rats, and, all things considered, is more generally successful in a combat with the big rodents.

Mr. Barkley says, in looking at ferrets where a number are stalled in straw in a tub for sale, he likes to see them dash out of their cover like furies, and spring up the sides of the tub snapping. Such ferrets have the right sort of fire for hunting and make the most valuable and gamy animals. In picking a ferret avoid all that have a thin appearance about the hairs of the tail and a black-looking dust at their roots, or if the underside of the feet are black and the claws incrusted with dirt; mangy beasts are worthless. In their behavior Mr. Barkley makes the following suggestions: if the ferret is vicious, hisses, arches its back and shows fight, it may be worth purchasing; but if it plays, dances, and seems full of spirit or fun, buy it at once. He never knew a playful ferret to turn out poorly. A ferret must be handled enough to expel from it all sense of fear and so trained as to "come to hand" readily. Keep ferrets in a box divided into three compartments, connected with each other by holes. The first serves as a nest or breeding box and is closed; the second is open on one side to the air and light, and is protected by a wire screen and has a cleaned floor always kept scrupulously neat; the third has a wire tray floor spread with sand, which must also be removed as often as is necessary to keep it clean and sweet. The holes connecting the compartments are closed and slides and lids over each compartment enable the keeper to inspect and clean the divisions. The whole box stands on legs about 1 ft. high. The straw to be used is wheat straw, *never* hay or barley straw, as these induce mange. Ferrets may be fed on bread and milk once or twice a week, but the tins should be well cleansed and only the freshest milk

PAIR OF JAPANESE FOWLS—LONG-TAILED BREED.

used. Their natural food is flesh, and birds, mice and rats are relished by them. They dislike the skin, and when fed, their boxes must be inspected and all skins and refuse from their meals cleaned out. Mr. Barkley feeds his ferrets on "work days" with bread and milk in the morning and nothing more until the hunt is finished.

When ferrets are ill with mange rub them with lard and sulphur, and after a hard day's work when the ferrets are badly, their wounds should be dressed with oil. In picking up ferrets bring the fingers under the forelegs so as to clasp the breast behind the neck at the shoulders, and so that the forelegs hang out over the hand. Ferrets will bite, but their bite is not to be feared.

Mr. Barkley takes his ferrets about in a strong canvas bag, and when he is using some of them takes care to put the bag down in a pleasant place, so that the ferrets are left in a comfortable condition. The moment a ferret has done its work put it back in the bag. The care and attention devoted to the perfect health of these animals will repay the rat catcher in their increased liveliness and thoroughness.

The ratting spade is indispensable. It serves many useful purposes in the field, stopping up holes and "rat runs" that are cleared out, knocking rats on the head and digging out burrows. Then the rat catcher must have his dogs; quick, spry rat killers. Mr. Barkley speaks very tenderly about his dogs and urges his pupils *always* to treat the dogs as their equals so far as food, shelter and sympathy goes. The more affection you can instill in a dog, the more trustworthy and efficient he will be in work. Mr. Barkley has a firm confidence in the superior intelligence of dogs. He says talk to your dogs, don't whip them. When you wish to train a dog not to kill a ferret, put a line on the dog, lay out the ferret, and when he dashes at it, say, "What are you up to! War ferret! Why, I gave four and sixpence for that, you fool, and now you want to kill it! Look here (picking up ferret and fondling it), this is one of my friends. Smell it (putting it near his nose). Different from a rat, eh! Rather sweet, ain't it? War ferret, war ferret! Would you, you rascal! Ain't you ashamed of yourself! War ferret, war ferret!" This formula gone over several times with a dog, and repeated when ratting, will so affect the canine sensibility as to keep the dog away from your ferrets with certainty.

Mr. Barkley has many amusing and interesting anecdotes and of course his experiences with rats are numerous and peculiar. He hunted rats in houses, in hay stacks, in fields, in hedges, in walls, in ditches, and wherever the requirements of his trade called upon him to pursue and eject them. His blunt, rollicking, out-in-the-air candor and ardor make his narratives attractive. L. P. G.

A LONDON IVORY SALE.

UPSTAIRS, here, along this quiet, dull corridor, we might almost imagine we are in some college or school, and it becomes difficult to free ourselves from the notion when, looking through a small glass panel in a door, we find what seems to be a lecture theater, fitted in the familiar manner with rows of desks rising one behind the other. Entering timidly we take our seats among the boys, many of whom are smoking, and each of whom has in front of him what looks like an examination paper, and a sheet of white foolscap for his answers. In the well is the lecturer, seated at the table of the usual build, and in front of him at a lower table is a row of excitable young men whom it is evidently advisable he should have under his eye.

"Say twenty-five," says the lecturer. And he says it, and no one takes any notice.

"Twenty-four ten," continues the lecturer. And there is a flutter of one white paper, but no one presumes to make a remark.

"Twenty-four!"—a pause—"twenty-three ten"—another pause—"twenty-three; twenty-two ten; twenty-two;"—in rapid succession—and no one betrays the slightest interest in the numbers.

"Twenty-one ten"—pause, punctuated by a sneeze—"twenty-one!"—pause. "Really, gentlemen, I withdraw. I would rather take them home and boil them for tea!"

And then there is a laugh all round, as might be expected, for the articles threatened to be boiled for tea are elephants' tusks, and this is an ivory sale in the Commercial Sale Rooms, Mincing Lane.

"Next lot," says the lecturer, whom we have now discovered to be a broker. "Twenty-four"—silence. "Twenty-three ten"—silence—"twenty-three." "Twenty-three ten!" says a voice. "Twenty-four!" says another, and then from all parts of the room a rapid firing of successive numbers and tens, tailing off into "twenty-nine ten—thirty—thirty ten!"

"Any advance on thirty ten?" asks the broker. "Any advance?" Knock goes the hammer. "Yours!" says the broker, nodding at a man on a back bench. "Next lot!"

And so it goes on, the broker putting the goods in at a trial price, and dropping by half sovereigns till the buyers take the chance, and then, outbidding each other, raise the price by half sovereigns to perhaps more than the broker's trial.

Four times a year, in January, April, July, and October, these ivory sales are held, and the display of the goods in the warehouse is one of the strange sights of London. The floor is crowded with ivory of all sorts and sizes, in tusks and sections, and odds and ends, some of it in huge teeth weighing 70 lb. each, some mere trifles of 20 lb. apiece, some mere pygmy "scrivelloes," and crooked, cracked, hollow, decayed and broken. On every lot is a big clumsy number, and every assemblage of lots has a notice board giving the broker's name and the first and last numbers of the lots he has to sell. The wilderness of teeth seems all in movement round the gigantic pair of traveling scales in the center; the curving tusks are like so many worms, all strangely scratched and scribed, and are of all colors from white, through the browns, to almost black; and an expert can tell at a glance where each came from, and can sort the lots from the pink Calcutta to the black West Coast which comes wrapped up in the raw hides bearing the mysterious name of "schroons."

What would an elephant think if he were to get a peep at this floor so crowded with his relatives' incisors? Here would be a *memento mori* for him more significant than that of the mummy at an Egyptian feast! Each pair of tusks means a life, for the elephant is as yet ignorant of the dentist's forceps, although we hear of elephants driven mad with the toothache and have specimens of tusk disease in our College of Surgeons' Museum; and the few cases of monstrosities having three, four, and even nine tusks at a time may be disregarded. Mr. Stanley tells us that in the Congo basin there are two hundred thousand elephants, each with 50 lb. of ivory in his jaws, the total being worth half a million of money; but even that stock would soon be exhausted if the Congo alone had to fill this floor four times a year.

And besides the London sales there are sales at Liverpool and Antwerp and Rotterdam. Most of the Liverpool ivory comes from the West Coast of Africa, and a quarter of it goes to Sheffield, a quarter to London, and half to Germany, France, and the United States. To the London sales the ivory comes from all parts. Recently the year's imports amounted to 11,763 cwt., declared at £537,527. Of this large quantity—the freight of which is reckoned at 16 cwt. to the ton—the British East Indies were responsible for 3,180 cwt., and Hong Kong for 40, thus making the Asiatic contribution 3,220 cwt., to which we must add 37 cwt. from Java and much of the 1,241 cwt. from Holland before we can approximate to the total yield of the Indian elephant. But a classification of this sort is vague and valueless. Ivory is both imported and exported direct by us, and much of it reaches us through European ports. For instance, Europe, omitting Holland, sends us 1,415 cwt., which may be either Indian or African, though the bulk undoubtedly comes from the dark continent. Much of the North African ivory reaches us by way of Malta, and much of the East African from Aden. Out of the 11,000 odd cwt. Malta sent 565 and Tripoli 309, making 874 as the Northern contribution; Aden sent 1,821 and East Africa 331,

making 2,152 as the Eastern lot; West Africa sent 2,429, and South Africa 181, making up the African supply to 5,636 cwt. at the very least, to which we should certainly add the French ivory from the Gaboon.

There was a time when, according to Polybius, the Ethiopian made his doorposts and fences of ivory; and when the ivory trade declined with the fall of Rome, the market became so glutted that ivory could be had for the asking. And according to native tradition the elephant, within a few centuries, was used as food, and his tusks were treated as bones, and thrown away. But that is not the case now, and through the length and breadth of the continent he is hunted for his teeth alone—not, however, for his eye-teeth, for he has none, but for his incisors. It is the timber problem over again. It takes as many minutes to cut down a tree as it took years to grow it, and it takes considerably more years for an elephant to grow his tusks than it takes minutes to kill him.

John Ray says that Vertomannus saw in Sumatra a pair of tusks weighing 336 lb., and there are records of single tusks weighing as much as 200 lb. But nowadays the ordinary tusks average about three to the hundredweight, so that 15,000 elephants have to be killed to furnish the British market, and some say 75,000 are killed a year. And as the elephant does not begin to breed until he is thirty years old, and averages but one youngster every ten years after that until he is ninety, the rate of increase is much too slow to overtake the slaughter.

To some people this would be no cause for regret. It has been said that were there no elephants there would be no negro slaves, and homilies as to the wickedness of ivory knife handles have been heard at dinner parties, to the edification at least of the homilist; but it is by no means certain that the last slave would disappear with the last elephant. The slave exists as a beast of burden, and so long as he remains the cheapest means of transport the substitution of one kind of merchandise for another is inevitable, and will make very little difference in his fate; and it is this consideration which has led so many of our leading men to see that the abolition of the slave trade depends, not on the extinction of the elephant, but on the growth of the railway.

But all the ivory does not come from Africa, a good deal of it comes from India; and a very little of the Indian ivory is obtained without killing the animal, owing to its being the custom to cut a captive elephant's tusk every ten years. From the Malay Peninsula and the islands thereabouts, there is a fair ivory trade direct with China, and the nests of balls, which are the highest achievement of ivory turning, are almost invariably made from the island teeth. These balls are a terrible puzzle until an hour or so's careful manipulation reveals how they are managed. By careful shifting it will be found that all the larger holes come opposite each other, and that it is down these shafts that the work has been done. The Chinaman has made probably fourteen holes in the solid ball, diminishing as they approach the center. Down the walls of these conical shafts he has spaced out the number of layers he requires, and beginning with the smallest ball, he has cut each layer free and carved it. It has been a long job evidently; and as a matter of fact he has worked five days, on an average, at each ball, and for his three months' work he was probably paid at the rate of five shillings a week, which is first-class pay for a Chinaman.

In Europe the great ivory-carving town is Dieppe. There is a wonderful story as to two little ships of Dieppe going off on a cruise as far back as 1364, and visiting the African coast, naming Cape Verd, and Bay of France and Petit Dieppe, and returning with spices and ivory, which has ever since been carved at the little Norman seaport. Be this as it may, there is no doubt as to there having been ivory carvers at Dieppe for very many years, and from there the art has spread to Boulogne, and Caen, and Paris. In England ivory is a substance for amateur turners to try enigmas on, but there is little carving, and our attention is mostly devoted to knife handles and billiard balls.

The tusks for billiard balls fetch the highest price in the trade; as much as £110 per hundredweight has been paid for them, which is more than double the rate for the ordinary kinds. As ivory ages, the water it contains evaporates, and for this reason the Tithe Commissioners will not use ivory scales, as the evaporation of the fluid makes them alter in length and breadth. The shrinkage is also taken account of in the billiard ball trade. The balls alter in the two diameters at different ratios if they are kept in a different temperature from that in which the teeth have been stored, hence the keeping of the teeth in large quantities, and the making of the balls out of tusks only a little bigger than themselves, so that there may be no margin in the ratio of shrinkage. Ivory keeps white longest if exposed to light under a glass shade, but in that position, as in museums, it dries as it gets old, and then it flakes, and has to be restored by boiling in gelatine.

There is a process for cutting the tusks in spiral shavings so as to obtain large sized sheets, and some such device seems to have been used by the ancients, not only for their tablets, but also for the faces and naked limbs of their heroic chrys-elephantine or toreutic statues, of which we have heard so much. The cutting up of a tusk in the ordinary way to the best advantage is a delicate operation. The saw is about two feet long, a fiftieth of an inch thick, and from an inch and a half to three inches wide; the teeth, five or six to the inch, sloping a little forward, at an angle between that of the hand saw and the crosscut saw. The tusk is never quite circular in section, and this irregularity has to be allowed for in marking out the cuts, and all along the center of the tusk there is a speck due the apices of the successive hollows, which also has to be dodged by the cutter; and sometimes he will find a bullet in the tusk to bother him, and rarely, very rarely, the bullet may be of the golden sort, used by Eastern potentates so frequently in fiction and so seldom in fact. No part of the tusk is wasted; the blocks go to the turner and carver and table knife maker, the spills or rinds go to the penknife maker, the sawdust, like the shavings, goes to the confectioner's as a stiffener for jellies, and to the lacemaker's as a dressing for curtains, and to other trades in which a strong fine size is required; the scraps go to the ivory black burner, and out of every hundredweight only 15 lb. remains to be burnt into black, which is, however, worth from £16 to £20 per ton.

After the ivory has been turned or carved it is polished on a wheel. The ivory worker's wheel is like a gigantic penwiper; it consists of round pieces of cloth screwed fast between disks of wood two or three inches less in diameter than the cloth, and thus affording a pliant edge projecting beyond the wood for the curvilinear surfaces of the umbrella or parasol handles, or whatever it may be that is submitted to its touch. Common work is polished on a series of wheels, one fed with Trent sand, one with loam, another, perhaps, with chalk; but better work is treated first, perhaps, with emery paper of the finest, made finer by rubbing two pieces face to face; secondly, with whiting and water thick as cream, used on wash leather or linen or cotton rag so thin that the fingers can feel through it; thirdly, with clean water; and fourthly, with a slightly oiled rag.

Both chemically and mechanically ivory is intermediate between horn and bone. It cannot be torn into filaments like horn, and it is not so brittle as bone, nor does it splinter. It is essentially equivalent to dentine, and the fine tubes running crookedly outward give it the grain in which much of its strength and beauty consists, and make it the most suitable material for ornamental turning and carving. Carving on ivory is almost as old as the mammoth, almost but not quite, for the mammoth must have had time to grow his tusks.

But ever since that distant epoch the white man seems to have fastened on to the tusk as material exactly appropriate for cutting on or in. From Nineveh and Assyria we have quite a famous collection of old ivories; we had the Greek statue of Minerva, forty feet high, in ivory and gold, and the equally famous one of Alcamenes, and many more; and as mere furniture we have thrones and chairs of all kinds, from Solomon's down to Tippoo's.

The mammoth fossil ivory, which, however, is not truly fossil, as it has undergone no fossilizing change, is a curiosity commercially, but at one time it was plentiful enough, the tusks being found in quantities in the Siberian ice. How strange it is that the old mammoth is never found south of a line drawn from the Pyrenees to Kamtschatka, while the modern elephant is never found north of that line except in captivity! Although rather brittle from age and treatment, the ivory of the mammoth is the same as that of the elephant, as indeed is the ivory of all the fossil species, not excepting the pygmy Falconer's elephant, which, when full grown, was not three feet high.

But all ivory does not come from the tusk, some comes from the grinder, and though it is not always easy to distinguish between an Indian and an African tusk, there is no doubt about the species when the molars are examined. There are now only two species of elephants, the Indian and the African. The Indian has molars with parallel folds, the African has them with lozenge-shaped folds; the other distinguishing marks being that the Indian has small ears, while the African has large ones, a yard long; the Indian's trunk has a finger at the upper lobe, while the African's trunk has both lobes much alike; the Indian's hind foot has four or five nails, while that of the African has but three, and the Indian is ten feet high, while the African is eleven.

But though elephant ivory is almost the only kind now seen on the ivory floor, there was, and is, a sort of ivory, commercially so called, coming from the hippopotamus and the walrus. The custom house description of ivory is, "Teeth, elephant's, sea cow, sea horse, or sea morse." Walrus ivory is poor stuff, the outer part of the tooth being alone of any good, the middle being more like coarse bone; but "sea horse ivory," which by some perversion has become the name for hippopotamus ivory, is harder all through than elephant ivory, and the outer coat of enamel is so hard that it resists steel and strikes fire, and has to be removed on the grindstone before the inner material can be worked. At one time sea horse ivory was chiefly used by dentists for artificial teeth, but the day for that has gone by, and the only ivory practically known to commerce is that of the elephant, which the disappointed broker threatens to boil for tea when it does not realize the price on which he can make a profit, and which costs on the spot in Africa about a third of what it is expected to sell for in Mincing Lane.—*Leisure Hour.*

BEFORE THE SALE.

IF wood is treated properly, it may be moulded in blocks in the shape of bricks. A hotel has been built in Hamburg entirely of compressed wood as hard as iron, and rendered absolutely proof against fire and the attacks of insects by subjection to chemical processes.

ON THE UNCERTAINTY OF CONCLUSIONS.*

By T. C. MENDENHALL.

ABOUT seven years ago, on the morning of a cold day in winter, a rough-looking, scantily dressed man was observed to leave a freight car, which was standing upon a side track near a small country town, and make his way rapidly into the fields and woods beyond.

From his appearance it was evident that he belonged to that vast army of tramps which is never in need of mobilization and which carries upon its muster rolls many who possess most of the virtues of the good and none of the vices of the bad, having lost only the power of further resistance against continued antagonism and unfriendly environment.

The behavior of this man excited no comment, and his existence was remembered a few hours later only because of the discovery of the body of a stranger, who had evidently been murdered, on the floor of the car which he had been seen to leave. Pursuit followed immediately, and capture within a day or two. One or two clever detectives interested themselves in finding evidence of his guilt, and within a few days had prepared a case which lacked little in the detail of its elaboration or in its artistic finish.

It was proved that two strangers were seen in the suburbs of the town at a late hour on the previous night, although they were not together. The prisoner was identified beyond doubt as the man who hastily left the car in the morning. The murderer had left no means of identification except a small piece of muslin, evidently torn from the sleeve of his shirt, and which was stained with the blood of his victim. On the arrest of the prisoner one or two blood stains were found upon his clothing, and, what was more convincing than all else, the bit of sleeve found in the car fitted exactly into the place in his own garment, from which it must have been torn in the struggle which preceded the crime.

While all of this evidence might be classified as "circumstantial," it was so complete and satisfactory that no jury could be expected to entertain serious doubt as to the guilt of the prisoner, and, in spite of his protestations of innocence, a sentence to life imprisonment was in accord with the judgment of the general public.

Only a few weeks since this man was set free and declared to be innocent of the crime for which he had already served seven years at hard labor, the misleading character of the evidence on which he was convicted having been exposed through the voluntary confession of the real criminal. The facts thus brought out were, briefly, as follows:

There were three men in the case. The first, who was afterward murdered, slept upon the floor of the car when the second, the real murderer, entered it. In the dark he stumbled over the sleeping man, who awoke and immediately attacked him. The quarrel did not last long, the original occupant being left dead upon the floor of the car while the murderer quickly made his escape, leaving the village and neighborhood behind him as far and as fast as possible. An hour or two later the third man, seeking shelter and sleep, finds his way into the car, and dropping on the floor, is soon in a deep slumber. He awakes at break of day to find that a dead man has been his companion, and to see that his own sleeve is smeared with the blood of the victim. Alarmed by this discovery, and realizing in some degree the perilous position in which he is thus placed, he tears off the stained portion of his garment, and, hastily leaving the car, he flees from the scene as rapidly as possible.

Nothing can be more simple or more satisfactory than this account of the affair, and yet nothing is more natural than that he should be accused of the crime and brought to trial. The evidence against him was convincing, and it was all absolutely true. It was not strange, therefore, that his conviction and imprisonment should follow.

It will doubtless appear to many that the foregoing is too closely allied to the sensational to serve fitly as an introduction to an address prepared for a society of philosophers, and I am ready to acknowledge the apparent validity of the criticism. I am led to its selection, however, because it is an account of an actual occurrence which illustrates in a manner not to be misunderstood a not unrecognized proposition to a brief exposition and partial development of which I ask your attention this evening. This proposition is that, in the treatment of many questions with which we are confronted in this world, our premises may be absolutely true and our logical processes apparently unassailable and yet our conclusions very much in error.

No department of human knowledge or region of mental activity will fail to yield ample illustration and proof of this proposition. An astonishingly large number of debatable questions present themselves to the human intellect. Many of them are conceded to be of such a nature that differences of opinion concerning them must continue, perhaps, indefinitely.

But there is a very large and a very important class of problems, the solution of which is apparently not impossible and often seemingly easy, regarding which the most diverse views are most persistently held by persons not differing greatly in intelligence or intellectual training.

Men whose business it is to weigh evidence and to reach correct conclusions, in spite of inadequacy of information and perversion of logic, constitute no exception to this statement, but, on the contrary, furnish many of its most notable illustrations.

Many of the questions which present themselves to our jurists and juries are simply questions of fact, and the testimony on which the determination of such questions depends often comes from persons who are neither interested nor dishonest. In such cases it ought to be easy to reach a true conclusion, but there is often failure, growing out of honest differences of opinion.

An eminent attorney not long since referred in conversation to a certain decision of the Supreme Court of the United States concerning which there had been a strong dissenting minority. The question was one which involved neither passion nor politics, and he declared that to him it seemed utterly impossible for a disciplined mind to reach other than one conclusion regarding it.

In any review of this subject, such as is here suggested, it is neither necessary nor proper to refer to the numerous instances of utter failure in our judicial system, attributable to a lack of integrity on the part of those who administer the laws or to the mischievous results of appeals to passion or prejudice by unprincipled advocates. It is sufficient to recognize the fact that failure in the administration of law is not uncommon where witnesses are honest, juries intelligent and well-meaning, and judges incorruptible.

The rapidly increasing number of controversies within the church, to say nothing of those in which the disputants are on opposite sides of the wall, show conclusively that the logic of the theologian must sometimes go at a limping gait. In political or social economy there is great diversity of opinion among good and able men. Certain financial legislation by Congress is honestly thought by many people to be necessary to prevent widespread disaster and the financial ruin of one of the largest and most important classes of our citizens; by other equally intelligent and equally honest men such action on the part of the national legislature is condemned as dishonest in principle and sure to be fatal to the business interests of the country.

A large number of able and patriotic men address themselves to the solution of the problem of the adjustment of duties upon imported merchandise. All have access to the same store of experience; the discussions and investigations of the past are open to all alike. In the end, however, their conclusions, even as to elementary principles, are diametrically opposed to each other.

But I have neither the time nor the disposition to enter into an exhaustive examination into the miscarriage of logic in the regions of politics, religion, or social science. I must restrict myself to some consideration of the uncertainty of conclusions reached by what may be broadly included under the general term "the exact sciences," a division of the subject not unlikely, I hope, to be of some interest to members of this society.

At the threshold of the investigation we are confronted by the term "exact sciences," and it is of the utmost importance to reach a clear understanding of the meaning of this phrase, in the beginning. By some writers its application is limited to the mathematical sciences or substantially to pure mathematics. This does not seem, however, to be in accord with the general usage among scientific men, and a wider significance will be here given to it.

Pure mathematics may, and possibly must be, regarded as a mode of thought; as symbolic logic; as an abridgment of mental processes by the selection of that which is common to all, and its formal expression by means of signs and symbols. Intellectual operations which, on account of their complexity and length, would be possible only to a few of the highest capacity are by the aid of mathematics brought within the range of the many. In virtue of the simple and beautiful nomenclature of the science, one can see at a glance, in a formula or equation, the various relations, primary and secondary, direct and implied, which exist among the several magnitudes involved, which, if expressed or defined in ordinary language, would be beyond the understanding of most intelligent people.

The principles and rules governing mathematical operations have been, in the main, so well worked out and so universally agreed upon that in mathematics one can hardly go astray, at least not without the certainty of almost immediate detection and conviction at the hands of many skilled in the use of this wonderful intellectual device. When dealing with quantity in the abstract, or with matter under just such restrictions or possessed of just such properties as are prescribed, mathematics becomes a machine of certain performance, the output of which can only be in error through the conscious or unconscious mistakes of the operator. As such it challenges the admiration of all, and it must forever be regarded as among the first, if not, indeed, the very first, of the few really splendid creations of the human intellect. When Plato, in reply to a question as to the occupation of the Deity, answered, "He geometrizes continually," he emphasized the dignity and the incontrovertibility of mathematical reasoning.

It is no reflection, then, upon the importance and value of the science of mathematics to leave it upon the pedestal which it rightfully occupies, considering it as separate and apart from other sciences. In their development it may and does play a most important part, in which, however, it is identified rather with the investigator than with the subject investigated; for, in studying the elementary principles of abstract dynamics, one may follow the now somewhat antiquated and cumbersome processes of Newton or the more simple and elegant methods of Clifford or Maxwell, but the results will in all cases be the same.

Before finally dismissing the pure mathematics, however, especial attention must be invited to one or two principles involved in their application by way of contrast with the condition of things which exists in the domain of the other sciences. It is sometimes declared by way of a criticism of mathematics that "what comes out of it is never better than what goes in." In a certain narrow sense this is true, but in a broader and truer sense it is as false as it would be to say that grain and fruit are no better than the soil from which they spring.

The mathematician has the great advantage over the physicist, the chemist, or the geologist that he not only can, but almost necessarily must, completely define the elements with which he has to deal. If he deals with matter, before he can put it into his equations he must needs restrict it as to form and dimensions and endow it with definite physical properties, the relations of which are capable of analytical expression. If, after this, his power of analysis is sufficiently great, the conclusions which he reaches can have no element of uncertainty in them, provided always they are considered as referring only to the supposititious material with which the investigation was begun.

That the conclusions are not in harmony with known phenomena is evidence only of the fact that the material of nature is not the material which is symbolized in the formula, and that certain properties which are common to both are modified in the former by the presence of others which are not attributed to the latter. When McCullagh, Neuman, Stokes, Sir William Thomson, or Maxwell each evolves a dynamical or mechanical theory of light, a lack of agreement among them or with known principles of optics can generally be traced to the fact that the medium in which they suppose the action to take place has not been endowed with the same common properties by all, and that in every case it falls short of an exact representation of the real ether itself. With this important restriction upon mathematical reasoning kept continually in mind, mathematics may be safely set aside as the "one science of precision."

What, now, are the characteristics of the so-called "exact sciences" other than pure mathematics? Without attempting a rigorous definition or a precise classification, it is sufficient for the purpose at hand to declare that the exact sciences are those whose conclusions are capable of being, and for the most part are, established by experiment and verified prediction.

Among these exact sciences the most notable, in degree of exactness, is the science of astronomy. Although the conclusions reached in the study of astronomy may not in general be established by experiment, the marvelous accuracy with which its predictions are verified has long ago placed it far in advance of other sciences. An inquiry into the cause of this excellence will not show that the logic of the astronomer is any more rigorous than that of many others engaged in scientific research, but rather that the premises on which he reasons are simpler, and, what is of greater importance, more nearly sufficient. Until a very recent period in its history, astronomy, although dealing with matter, has been concerned almost entirely with only one of its many properties. The one property thus far assumed to be common to all matter is that long known but still mysterious attraction in virtue of which there exists a stress between every particle and every other particle in the universe, according to a law the discovery and exposition of which justly entitles Newton to be considered the greatest philosopher of all ages. It happens that the hundreds and possibly thousands of other properties possessed by, or inherent in, matter have little if any influence on the dynamics of masses widely separated from each other, and therefore a knowledge of the law of gravitation seems to be sufficient to enable the astronomer, having, of course, obtained the necessary data from observation, to trace the paths of the planets and to foretell the configuration of the heavens many years in advance. Within the past twenty-five years, however, the splendid discovery of spectroscopy, aided by great improvements in photography, has given rise to a new astronomy, known as physical, as distinguished from gravitational astronomy.

The new science deals with a matter of many properties, some of which are but little understood. While its conclusions are of vital importance and of intense interest, they result from deductions in which the premises are insufficient and are proportionately uncertain. The new astronomy must for a long time abound in contradictions and controversies until, and largely through its development, we shall possess a knowledge of the properties of matter when subjected to conditions differing enormously from those with which we are now quite familiar. Because one astronomer declares that the temperature of the sun is 20,000° F., and another, equally honest and capable, says it is not less than 20,000,000° F., it must not be inferred, and it never is, except by the superficial, that the whole science of solar energy is a tissue of falsehoods, and that those engaged in its development are deliberately planning an imposition upon the general public. Even such widely varying results as these may be based on observations that are entirely correct and experiments that are beyond criticism. The discussion of the results obtained by observation and experiment may follow, in both cases, the very best models, and yet the conclusions may be erroneous and contradictory, owing to the insufficiency of data in the beginning.

Unfortunately the omission of one or more important quantities from the equations of condition is not always known or suspected. The older, more exact astronomy is occasionally caught tripping in this way. An interesting example of recent occurrence is to be found in certain observations for stellar parallax made a few years ago by members of our own society. The observations were long continued, the instruments used were of a high character, and the observers were skillful. These conditions unquestionably promise success. It was something of a surprise, therefore, when a reduction of the observations gave for the parallax a negative result. As such a result could in no way be possible, except, perhaps, through the assistance and intervention of a curvature in space (in virtue of which if a man's vision was not limited he would, by looking straight forward, see the back of his own head), it was assumed that the work was not as well done as it seemed to be, or that some imperfection in the instrumental appliances had been overlooked. It now appears, however, that this record may be reopened, and that the results may prove to be of as great value as originally anticipated. Researches carried on during the past year or two have with little doubt established the fact that the latitude of a point on the earth's surface is not a fixed quantity, but that, on the contrary, it varies through a small range during a period somewhat greater than a year. It is believed that if this hitherto unsuspected variation be applied to the parallax observations referred to above, the seeming absurdity of the result will vanish.

If astronomy, the foremost of the exact sciences, is not free from the fault of basing conclusions upon insufficient premises, it will not be expected that among other sciences the evil will be of less magnitude.

When we consider the sciences of heat, light, electricity, magnetism, and other specially investigated properties of matter, all of which are usually included under the general head of "physics," we meet with a formidable rival of astronomy in the extent to which they are entitled to be considered as exact sciences.

Physics treats of all the properties of matter, not

* Address as retiring president, delivered Jan. 30, 1892, before the Philosophical Society of Washington.—*Science.*

omitting that which is the special domain of astronomy. As if this were not enough, the demands upon the science are such that it must also deal with that which is not matter, or, at least, is not matter in the ordinarily accepted sense. Although physics deals with all of the properties of matter, no physicist knows them, or, possibly, half of them. Perhaps not one of them is entirely and completely known. It would seem, therefore, that this science must of necessity be one of uncertain conclusions. That it is far from deserving so sweeping a criticism is due to the fact that the properties of matter are not so closely interrelated as to make it impossible to isolate one or more of them in experiment, and thus the problem is vastly simplified. It is probably impossible to do this rigorously in any case, so that there must always remain a small residuum of uncertainty due to the interference of unknown or imperfectly understood properties of matter.

Thus it is possible to treat a mass of matter as though it possessed mass only, ignoring its electrical, magnetic, or optical properties, its relation to heat, its elasticity, and other physical characteristics, and investigate its behavior under the law of gravitation alone; its optical properties may be found to be nearly independent of its relation to heat, electricity, magnetism, etc., and so, in turn, each characteristic may be studied alone and equations obtained in which the number of constants is comparatively small. It is only after this plan has been pretty thoroughly worked out that it becomes possible to investigate the interrelations of these various properties, which are often obscure and difficult of detection. Their discovery, however, especially one or two great generalizations pertaining to them, such as that of the conservation of energy, must be regarded as the grandest triumph of physical science.

The science of physics is that which is most drawn upon in the formation of the so-called applied sciences. Wedded to mathematics as it is (and no amount of personal abuse on either side can ever furnish good reason for divorce), it becomes the mother of engineering in all of its various forms. Through and by it, the forces of nature have been directed, the elements have been subdued and some of them overcome, and man has made himself master of the world. Its marvelous progress has, therefore, been observed by the people, and is understood by them perhaps to a greater degree than that of any other science. The most eloquent orators and the ablest writers have employed their genius in sounding its praises.

It is not too much to say that when intelligent people speak, in a general way, of the wonderful things which science has accomplished during the past half century, they have in mind, for the most part, the applications which have been made of discoveries in physical science. I think no one can justly question the assertion that of the several causes which have produced the splendid advances in the material interests of the whole world during the nineteenth century, science has contributed far more liberally than all others. So remarkable have been her achievements that all the people have come to look upon her as being nearly, if not quite, infallible. A reputation of which the votaries of science may be proud has been established, but, at the same time, one difficult to maintain. Here, as elsewhere, it is a good name only that is worth counterfeiting. It is quite worth the while of one devoted to the interests of pure science alone to occasionally inquire whether an impure article is not being placed upon the market. However indifferent he may be to the welfare of the general public, his own selfish instincts should incline him to such a course. He cannot clear his own skirts by declaring that the public deserves to be humbugged if it permits itself to be, for in this, as in everything else, the counterfeit when successful is not readily detected, and it is often made to appear more attractive than the genuine article.

In respect to this matter, physical science presents two aspects. In a large degree it is a science of certain conclusions, and any false deduction is readily exposed by means of the many severe tests to which it may be subjected. On the other hand, in some of its branches it has not yet been found possible to isolate the elements which form a rather complex whole, and it therefore remains an observational rather than an experimental science. In the latter aspect it becomes comparatively easy prey for charlatans and well-meaning but ignorant non-professionals.

In no department of physical science is this better illustrated than in meteorology, the oldest and most abused of all sciences. From its early days, when weather forecasts were expressed in simple rhyme, to the present, when they are issued in a prose which in its scope and richness of vocabulary sometimes excites our highest admiration, meteorology has been a favorite victim of pretenders, conscious and unconscious. For years the people, after having first believed in, have patiently borne with, the predictors of disaster in the form of abnormal meteorological disturbances. They have suffered great mental distress, and they have lost enormous sums of money on account of floods, tidal waves, and earthquakes which never came, rains that never fell, and winds that never blew. They were becoming accustomed to this sort of thing, and were beginning to understand the spirit which guided the real meteorologists as manifested in the efforts of the great weather bureaus of the world, our own among the first, to foretell with a good degree of certainty what might happen within the next twenty or thirty hours. But not many months ago they were again brought to a high pitch of meteorological excitement by the somewhat sudden and certainly unexpected appearance of the "Cloud-compelling Jove." He came not in the singular, but in the plural, and each of him brought the best and most scientific device for producing a rainfall whenever and wherever a sufficient thirst was found to exist. The history of this new industry cannot yet be written. It is still in its infancy. The fallacy of its methods has already been commented upon in a public journal, by a distinguished member of our own society, but a few remarks upon its somewhat meteoric career during the past season will not be out of place in connection with the subject now under consideration.

The columns of the daily press reflected the general interest which was felt in the matter, especially in parts of the country where rainfall was greatly needed. As is always the case under such circumstances, the strong and entirely natural desire that its artificial production might be accomplished was soon converted into a belief that it had been, and a readiness to accept the flimsiest sort of evidence of relation between the means employed and the end sought. This confidence materialized, or better, perhaps, was taken advantage of in the formation of an "Interstate Artificial Rain Company, Limited" (I am quoting from the daily papers of Nov. 10, 1891), which, after the manner of its kind, was apparently organized not for the purpose of actually producing rain, but for the formation of other joint stock companies ready to purchase the secret method of doing it. An alleged experiment, on which a business transaction was based, is thus described:

"The party arrived in the city on Sunday, Nov. 1, and commenced operations on Sunday evening in a small outhouse on the edge of town. The conditions were extremely unfavorable for rain. No results could be seen at first, but on Friday the sky became overcast with clouds. On Saturday a high south wind prevailed, and on Saturday night some rain came from the southwest. On Sunday rain fell all day, and at night a norther arose. Reports from 100 to 150 miles around this town show that rain fell on Sunday in most localities in considerable quantities." So convincing was this to the buying company that the secret process was purchased by them for the sum of $50,000, "after which," the account rather unnecessarily adds, the selling company "left for home." But a business so profitable as this was not to be long without competition, and a few weeks later a telegram is sent to the leading papers of the country, announcing that a professor in a Western State (it is pleasant to note that most of these public benefactors are "professors") is prepared to furnish rain more promptly and at less cost than the genius whose machinery and methods have invited public approval. Proposals to do the county sprinkling at so much per acre are invited and offered, and at one time it seemed as if the whole business would be ruined by over-production.

One of the most interesting phases of this subject was the attitude in reference to it assumed by a large part, possibly the greater part, of the intelligent public. It was one of expectancy and limited confidence. "Why not?" was commonly asked. "Look at what science has done within the last twenty-five years. Can anything be more astonishing? And is the artificial production of rainfall more difficult and more wonderful than many things which are now commonplace?" To many the logic of the experiments was convincing. After many battles rain had fallen, long lists of examples have been prepared, and hence it must be possible to produce rainfall by cannonading. If these views were entertained by a considerable number of intelligent people, and it is believed that they were, the situation is one which ought to be full of interest to men of science, involving as it does both a tribute and a warning.

It would be good for all if the intelligent public was in the habit of looking a little more below the surface of things. It is too much in the way of assuming that the president of the company engaged in exploiting an important invention or device is the genius who first discovered the principle in virtue of which it operates. It loses sight of—no, it does not lose sight of, because it never knew—the patient toil, the unselfish devotion, and, what is perhaps more important, the unflinching honesty with which a few men of the highest intellectual capacity have from the earliest times given themselves to the study of the laws of nature.

It would surprise the public to know how long ago and by whom many of the most recent and most brilliant applications of science were made possible. Would it not be in the interest of all if men of science were more ready and willing to take the intelligent public into their confidence; and would not the public, if familiar with the history of scientific investigation and accustomed to scientific modes of thought and criticism, be less the prey of charlatans and well-meaning but ill-informed enthusiasts? A better knowledge on both sides would lead to a better appreciation of both sides, and the real worker in science would seldom go without that public recognition which has too often been denied to the ablest men. No better illustration of this can be found than in the life of the distinguished first president of this society, to stand in whose place must always be an honor to any man. With his great work as secretary of the Smithsonian Institution the public is fairly well acquainted, and it has not been backward in bestowing honors in recognition of that work. Unfortunately, comparatively few know of what must be regarded, I think, as his greater work, the original researches in which he was engaged, and in which he was so singularly successful, before he became identified with the institution to which he gave the greater part of his life. Scant justice has yet been done to this important part of a career which must always be an inspiration to members of this society.

But I am warned that the brief time during which I can claim your attention to-night is quite insufficient for anything like a full exposition of the theme which I have selected, and I must, I fear, somewhat abruptly turn about in order that I may leave with you in somewhat more definite language one or two thoughts which I have attempted to develop by illustration and example.

Recurring to the unfortunate victim of circumstantial evidence, whose experience was related in the beginning, it will be admitted that the judge who charged, the jury who convicted, the witnesses who told the truth, and the approving public were all in error, in that they failed to recognize that there was another way of explaining what had happened. It does not necessarily follow that the explanation which explains is the true one. There are many natural phenomena which are in entire accord with more than one hypothesis. Indeed, there are some things which may be perfectly accounted for on an infinite number of suppositions, but it does not follow that all or any one of them must be accepted. There is nothing especially novel in this proposition, but I submit that to a failure to keep it in sight must be attributed a large measure of the uncertainty of the exact sciences, as well as much useless and bitter controversy in science, religion, ethics, and politics.

As a sort of corollary to this proposition I suggest that many reasoning and reasonable people are indifferent to, if not ignorant of, the fact that the value of evidence is greatly dependent on the way in which it arranges itself. To many this may be made a little clearer if I borrow a phrase from one of the most exact of modern sciences and speak of evidence as presenting itself in series or in parallel. Without pushing the analogy further, the superior strength of the latter arrangement will be evident upon reflection. On another occasion, I have referred at some length to the numerical representation of the value of testimony, and to some conclusions which are easily reached. As bearing upon the subject in hand, a single example of this method of treatment may be useful.

Let there be two witnesses, A and B. Suppose that A tells the truth 51 times out of 100; that is to say, assume that honesty holds the controlling share in his stock of moral principles. Let B be equally truthful and no more. Then if these two testify independently to the occurrence of a certain phenomenon, it is more likely to have occurred than if either one alone bore witness. This is evidence in parallel. If, however, A testifies that B declares that the thing happened, it is less probable than if based on the testimony of either alone. This is evidence in series. Put as boldly as this, no one doubts the higher value of the first arrangement; but it is believed that a more careful consideration of this distinction will do much to secure a better judgment, not only where human testimony is involved, for here it has long been an established principle, but where conclusions are based on observation and experiment.

It is of the utmost importance, therefore, that men of science, before accepting a theory or a hypothesis as final, should carefully scrutinize the steps by which it has been established to see that they are not only sufficient but necessary. The true philosopher will be slow to claim that the theory which he finds sufficient to explain all of a given class of facts is the necessary and true one; he will be constantly on the lookout for a new fact which his theory will not quite explain, and he will have much consideration for his friendly competitor who finds a different hypothesis equally satisfactory and efficient. Above all, he will not pride himself on the steadfastness of his views, and will rarely bind himself to be of the same opinion this year as last.

If the general public could be made to understand the limitations by which science is circumscribed, the tentative and ever progressive character of scientific investigation, it would be good for the public and good for science.

The human race is greatly handicapped by the presence of a good number of people who strenuously object to being disturbed. During a decade, generation, or century these good but sometimes unpleasant people plant themselves along certain lines in the domain of science or politics or religion, proclaiming essentially that "here and here only is the truth, and here we fix ourselves forever." After awhile they somewhat unwillingly and with no very good grace move forward into a new position, again honestly affirming and believing that the end has been reached. A better knowledge and a broader human sympathy would reveal to them the hitherto unsuspected fact that truth may at the same time be here and there.

In the dissemination of this knowledge and the cultivation of this sympathy, science should lead, not follow. No scientific organization so young in years has done more along these lines, especially by reason of its extensive membership and the vigor and enthusiasm of its branches, than the society over whose deliberations during the past year I have been permitted to preside.

For the honor thus bestowed I beg now to make my formal and grateful acknowledgments.

THE FOURTH CENTENARY OF COLUMBUS.

DURING the present year great celebrations will take place in Spain, Italy, and America, in memory of Columbus and his first adventurous voyage of 1492. Although no public commemoration is arranged for in England, the Royal Geographical Society, fully conscious of the momentous nature of that first voyage, and of the enormous expansion of geographical science which has resulted from it, set apart Monday, June 20, for a special Columbus meeting. The usual exhibition of maps and pictures included a number of early charts of great beauty, and a fine photograph of a contemporary portrait of Columbus, recently made known by Mr. Markham. The paper of the evening, read by Mr. Clements Markham, C.B., F.R.S., was occupied with an account of recent discoveries with regard to Columbus, and the correction of many erroneous ideas widely entertained until now. As a critical summary of perhaps one of the most difficult branches of research—that into the actual life of a popular hero enhaloed with centuries of tradition—this paper is of great value. An abstract of it, and of the appendices on other fifteenth century explorers, is given below.

Much new light has been thrown upon the birth and early life of Columbus of late years by the careful examination of monastic and notarial records at Genoa and Savona.

There is no doubt as to the birthplace of Columbus. His father was a wool weaver of Genoa, whose house was in the Vico Dritto di Ponticelli, which leads from the gate of San Andrea to the church of S. Stefano. It was battered down during the bombardment of Genoa in the time of Louis XIV., was rebuilt with two additional stories, and is now the property of the city of Genoa.

Here Columbus was born, the date of his birth being fixed by three statements of his own, and by a justifiable inference from the notarial records. He said that he went to sea at the age of fourteen, and that when he went to Spain in 1485 he had led a sailor's life for twenty-three years. He was, therefore, born in 1447. The authorities who assign 1436 as the year of his birth rely exclusively on the guess of a Spanish priest, Dr. Bernaldez, Cura of Palacios, who made the great discoverer's acquaintance toward the end of his career.

The notarial records, combined with incidental statements of Columbus himself, also tell us that he was brought up, with his brothers and sister, in the Vico Dritto, at Genoa; that he worked at his father's trade and became a "lanerio," or wool weaver; that he

moved with his father and mother to Savona, in 1472; and that the last document connecting Cristofero Colombo with Italy is dated on August 7, 1473. But in spite of his regular business as a weaver, he first went to sea in 1461, at the age of fourteen, and he continued to make frequent voyages in the Mediterranean and the Archipelago—certainly as far as Chios.

When Columbus submitted his proposition for an Atlantic voyage to the Spanish sovereigns, they referred it to a committee, presided over by Father Talavera, which sat at Cordova and condemned it as impracticable. It is generally supposed that the proposals of the Genoese were subsequently submitted to an assembly of learned persons at the University of Salamanca, and again condemned. The truth was quite different. Columbus was gifted with a charming manner, simple eloquence, and great powers of clear exposition. It was an intellectual treat to hear him recount his experiences and the arguments for his scheme. Among those who first took an interest in his conversation, and then became a sincere and zealous friend, was the prior of the great Dominican convent of San Estevan and professor of theology at Salamanca, who shrewdly foresaw that the most effectual way of befriending Columbus would be by affording ample opportunities of discussing the questions he raised. For this object there could be no better place than the University of Salamanca, where numerous learned persons assembled, and where the Court was to pass the winter. The good prior lodged his guest in a country farm belonging to the Dominicans, called Valcuebo, a few miles outside Salamanca. Hither the Dominican monks came to converse on the great deductions he had drawn from the study of scientific books, and from his vast experience, discussing the reconciliation of his views with orthodox theology. Later, in the winter, Columbus came into the city and held conferences with men of learning, at which numerous courtiers were present. These assemblages for discussion—sometimes in the quiet shades of Valcuebo, sometimes in the great hall of the convent—excited much interest among the students and at Court. The result was that the illustrious Genoese secured many powerful friends at Court, who turned the scale in his favor when the crucial time arrived. Such is the slight basis on which the story of the official decision of the Salamanca University against Columbus rests.

Captain Duro, of the Spanish navy, has investigated all questions relating to the ships of the Columbian period and their equipment with great care, and the learning he has brought to bear on the subject has produced very interesting results. The two small caravels provided for the voyage of Columbus by the town of Palos were only partially decked. The Pinta was strongly built, and was originally lateen rigged on all three masts, and she was the fastest sailor in the expedition; but she was only 50 tons burden, with a complement of eighteen men. The Nina, so called after the Nino family, of Palos, who owned her, was still smaller, being only 40 tons. The third vessel was much larger, and did not belong to Palos. She was called a "nao," or ship, and was of about 100 tons burden, completely decked, with a high poop and forecastle. Her length has been variously estimated. Two of her masts had square sails, the mizzen being lateen rigged. The crew of the ship Santa Maria numbered fifty-two men all told, including the admiral.

Friday, August 3, 1492, when the three little vessels sailed over the bar of Saltes, was a memorable day in the world's history. It had been prepared for by many years of study and labor, by long years of disappointment and anxiety, rewarded at length by success. The proof was to be made at last. To the incidents of that famous voyage nothing can be added. But we may at least settle the long disputed question of the landfall of Columbus. It is certainly an important one, but it is by no means a case for the learning and erudition of Navarretes, Humboldts, and Varnhagens. It is a sailor's question. If the materials from the journal were placed in the hands of any midshipman in Her Majesty's navy, he would put his finger on the true landfall within half an hour. When sailors such as Admiral Becher, of the Hydrographic Office, and Lieutenant Murdoch, of the United States navy, took the matter in hand, they did so. Our lamented associate, Mr. R. H. Major, read a paper on this interesting subject on May 8, 1871, in which he proved conclusively by two lines of argument that Watling Island was the Guanahani or San Salvador of Columbus.

The spot where Columbus first landed in the New World is the eastern end of the south side of Watling Island. This has been established by the arguments of Major, and by the calculations of Murdoch, beyond all controversy. The evidence is overwhelming. Watling Island answers to every requirement and every test, whether based on the admiral's description of the island itself, on the courses and distances thence to Cuba, or on the evidence of early maps. We have thus reached a final and satisfactory conclusion, and we can look back on that momentous event in the world's history with the certainty that we know the exact spot on which it occurred—on which Columbus touched the land when he sprang from his boat with the standard waving over his head.

The discoveries of Columbus, during his first voyage, as recorded in his journal, included part of the north coast of Cuba and the whole of the north coast of Espanola. The journal shows the care with which the navigation was conducted, how observations for latitude were taken, how the coasts were laid down—every promontory and bay receiving a name—and with what diligence each new feature of the land and its inhabitants was examined and recorded. The genius of Columbus would not have been of the same service to mankind if it had not been combined with great capacity for taking trouble and with habits of order and accuracy.

Columbus regularly observed for latitude with Martin Behaim's astrolabe or the earlier quadrant, when the weather rendered it possible, and he occasionally attempted to find the longitude by observing eclipses of the moon with the aid of tables calculated by old Regiomontanus, whose declination tables also enabled the admiral to work out his meridian altitudes. But the explorer's main reliance was on the skill and care with which he calculated his dead reckoning, watching every sign offered by sea and sky by day and night, allowing for currents, for leeway, for every cause that could affect the movement of his ship, noting with infinite pains the bearings and the variation of his compass, and constantly recording all phenomena on his card and in his journal. Columbus was the true father of what we call proper pilotage.

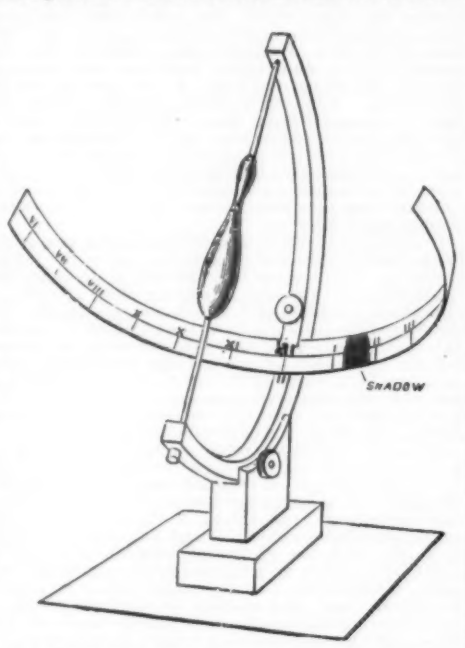
On his return his spirit of investigation led him to try the possibility of making a passage in the teeth of the trade wind. It was a long voyage, and his people were reduced to the last extremity, even threatening to eat the Indians who were on board. One night, to the surprise of all the company, the admiral gave the order to shorten sail. Next morning, at dawn, Cape St. Vincent was in sight. This is a most remarkable proof of the care with which his reckoning must have been kept and of his consummate skill as a navigator.

In criticising the Cantino map showing Cortoreal's coast lines, Mr. Markham showed that absurd mistakes had been made, not by the voyager or his pilots, but by the cartographer and subsequent commentators. Vespucci's description of his "first voyage," in 1797, was subjected to very thorough criticism, and shown, in spite of the arguments of authors who have tried to support the veracity of that ingenious romancer, to have been a pure fabrication. Little or no credit could be given to Vespucci in any case, as he was forty-eight years old on first going to sea, and in those days apprenticeship from boyhood was indispensable for a knowledge of seamanship.—*Nature.*

IMPROVED MEAN TIME SUN DIAL.

MOST people know that the ordinary sun dial does not give true mean or clock time; what it indicates being apparent time, which may differ from the other by as much as sixteen minutes. The difficulty has been got over in an invention by Gen. J. R. Oliver, of London. The peculiarity of the instrument is that the time is indicated, not by the shadow of a straight edge, as in the old sun dials, but by the point where an equatorial circular line is cut by the edge of the shadow of a curved surface, the curvature of which is so arranged as to compensate for the "equation of time."

The instrument is a universal one, and consists of a meridianal semicircle, the diameter of which is an axis carrying the curved gnomon, and an equatorial circular arc. The latter has engraved upon its concave surface a graduated line on which are marked the hours



IMPROVED MEAN TIME SUN DIAL.

and their subdivisions. There is a screw for clamping the meridianal arc at the proper position for any given latitude, and another clamp for adjusting the equatorial arc.

The dial not only indicates local mean time, but by a very simple adjustment may be set so as to show any required standard time. Thus it might be set at Plymouth to indicate Greenwich time. Strictly speaking, there ought to be two gnomons, one to be used from June to December and the other from December to June. But by adopting a gnomon of mean contour the greatest error introduced at any time is only about one minute, an amount not more than the unavoidable one due to the softness of the edge of the shadow. Four times a year the equation of time vanishes, and the gnomon would then intersect its own axis. To allow for the necessary thickness of the latter, a slight adjustment of the hour circle is necessary at these times.

Although the invention is little more than a scientific toy so far as England is concerned, it is believed that it would be of great use in countries where sunshine is plentiful and means of regulating the time are scarce. South Africa, South America, Australia, and India may be adduced as instances.

In India, for example, there are numerous up-country stations at a distance from any railway, where there are practically no means of correcting clocks and watches. Egypt, however, is the land of all others for sun time, consisting as it does of a narrow strip of country running nearly north and south. Its cloudless sky and the habits of its people hardly give any other system of reckoning time a chance. A gun at the citadel at Cairo used to be fired by the sun by means of a burning glass at noon every day, and probably is still so fired. The fight between the sun's apparent time backed by the gun, against mean time, used to be very funny. With the native population, we take it the sun and the gun still have it all their own way.—*The Engineer.*

[From the AMERICAN NATURALIST.]

MENTAL EVOLUTION IN MAN AND THE LOWER ANIMALS.

By ALICE BODINGTON.

THE science of psychology is at last emerging from the cloudland of metaphysics in which it has been enveloped from immemorial ages. Deep would be the folly of the man who would declare that we know what mind or consciousness really *is*, but at least we are beginning to understand something of its phenomena on the physical side, and to recognize that even the human mind is a product of evolution. Whether an impassable gulf, or a Rubicon which can be boldly and safely crossed, separates the human mind from mind in the lower animals, is still a moot point with men of the highest scientific repute.

I do not for a moment pretend to approach the question from the high metaphysical point of view, but only to apply to the subject the same method which has so successfully been applied in biology; to put theories on one side, until we have ascertained as many ordinary facts as possible. In biology the greatest triumphs have been obtained by the demonstration that ontogeny, the history of the individual, is a guide to phylogeny—the history of the race. And in examining the history of the race, we find the development of the lower species of animals an invaluable guide in understanding the development of the higher species. Moreover, if we wish to understand the peculiarities of domesticated animals, we must study the habits of their wild relations. These three guides we may take in studying the development of the human mind: in the child we may study its ontogeny; in the development of intelligence in animals we can observe the dawn of faculties which attain their supreme expression in man; and in the more primitive or savage races of man, we may see the germ which contained the nucleus of our civilization.

In the child, we find at the beginning of life a mental condition as low as that of a blind puppy or a kitten, showing two instincts only,* of which one has but lately been revealed; and no glimmerings, for many months, of reason. From this humble beginning to the highest point which human faculties can reach, there is no break; no point at which we can say "Here mind exists, where yesterday it was not." Not only is the growth of the human mind gradual, but during its earlier phases of development it assuredly ascends "through a scale of mental faculties parallel with those permanently presented by the lower animals, while with regard to the emotions the area these cover in the lower animals is nearly co-extensive with that covered by the emotional faculties of man."† The purely human *emotions* may indeed be limited to religion and the sense of the sublime.

And if from the history of the individual we turn to all we know of the history of the race, the evidence of a gradual evolution of mental faculties is the same; from the rough flint weapons of the drift period to the era of polished stone; from polished stone to bronze; from bronze to iron; from the fetich of shapeless wood stuck with feathers, and the merciless nature gods, which men saw in sunshine and storm, in famine and in pestilence, to the Brahma of the Vedas and the God of Isaiah; from the rude sticks covered by skins of animals, and shelters of rough piled stones, to houses of wood and hewn stone, and thence to such conceptions as are embodied in the Parthenon, or in the cathedrals of the middle ages, we have similar evidences of evolution. And whatever point of view we take we see progress starting from the humblest beginnings; no matter how towering the building, its foundations are laid deep in the earth.

It has been alleged that this very progress in human affairs draws a sharp line of demarkation between men and animals; that whereas in man a constant improvement goes on, no sign of progress can be found in brutes. This argument is weak on both sides. On the one hand, though constant and even rapid improvement is a characteristic of certain races of men, yet there are numerous races whose improvement is either stationary or incredibly slow. They are to other men what the Lingula, which has remained unchanged since Cambrian times, is to other invertebrates. There are savages still in the age of unpolished stone; savages whose religion is the lowest fetich worship; savages whose only refuge is a skin spread over a few sticks, and others to whom any kind of shelter is unknown. Some progress they have all made from the furry arboreal animal with pointed ears, but it has been a progress immeasurably behind that of the higher races of man. "Rapid and continuous improvement," in the words of Mr. Romanes, "is a characteristic of only a small division of the human race, during the last few hours, as it were, of its existence." The wonder is that with articulate language man should have improved so slowly.

On the other hand it would be impossible to deny the great improvement which has taken place in the mental and moral qualities of the dog, when we compare him with the wolves and jackals from which he is descended. He has won for himself a tribute of praise from some of our noblest poets; a tribute richly due to his devoted love and fidelity. Hear Wordsworth's lament:

"Tears were shed
Both man and woman wept when thou wert dead;
Not only for a thousand thoughts that were
Old household words in which thou hadst thy share,
But for some precious boons vouchsafed to thee,
Found scarcely anywhere in like degree,
For love that comes to all, the holy sense,
Best gift of God, in thee was most intense;
A chain of heart, a feeling of the mind,
A tender sympathy which did thee bind,
Not only to us men but to thy kind:
Yea for thy fellow brutes in thee we saw
The soul of love."

And Byron writes not less warmly:

"The poor dog, in life the firmest friend;
The first to welcome, foremost to defend,

* The instinct, pointing surely to an arboreal ancestry, by which a new-born infant will cling to a support unaided.

† Romanes: Mental Evolution of Man.

Whose honest heart is still his master's own,
Who labors, fights, lives, breathes for him alone,
Unhonored falls, unnoticed all his worth,
Denied in heaven *the soul he held on earth*."

There can be little doubt that if other animals had been valued for their moral qualities, had these been carefully developed from generation to generation, they would have shown a like or a greater improvement. The intellectual qualities shown by trained elephants, which in their youth have roamed wild through the forests, are so marvelous that it is difficult to imagine or estimate what the intelligence of the race might become after a few generations of cultivation. And the same rema k applies to the acuteness of intellect shown in captivity by many apes and monkeys, which have been brought fresh from their native woods. What progress would creatures so intelligent, so teachable, so insatiably curious and so persevering, make after a few generations of culture?

But putting aside the great development in the psychology of the dog, we have in paleontology the most unanswerable evidence of the vast improvement which has taken place in the *brains* of mammals since Eocene times.

In our own day the brains of the higher mammals show a great increase in the cerebrum, the part of the brain concerned especially with intellectual functions, and its surface is greatly increased by convolutions. Gradually as we go back in geological time the cerebral hemispheres are smaller, then they no longer cover the mid-brain, and the latter shows distinctly, as in reptiles and fishes there are of course no convolutions, and finally in the Eocene we meet with mammals, immense in size, but with the brains of reptiles.*

A faulty nomenclature has probably had a great deal to answer for in the tardy recognition of the intellectual powers of the lower animals. Ideas have been divided into "simple" and "general," or into "concrete" and "abstract." It was impossible to deny the existence of simple ideas in brutes, but it was, and is, contended that they are incapable of abstract ideas. Mr. Romanes points out the existence of a wide territory between simple and abstract ideas, and he proposes a threefold definition of ideas to which he gives several names. It will make the question clearer if we take three of these names and speak of simple, complex and abstract ideas; or of percepts, recepts and concepts.

This definition can be illustrated by taking the word "star." The recognition of one particular star is a simple idea or percept, the recognition of a number of stars, or of bright, twinkling objects resembling the shining of stars, is a complex idea or recept. So far the mind of the higher brutes keeps pace with the developing mind of man. But the next step carries us beyond the mental powers both of infants and of animals; neither can conceive the idea of a star as present to the mind of an astronomer. This is an abstract idea or concept, and is unattainable except through the medium of articulate language. Where the child sees a twinkling spark, the astronomer is conscious of a flaming sun; where, until lately, men recognized the symbol of unchangeableness, the astronomer knows he beholds stupendous worlds rushing through space at unimaginable speed; where the Hebrew seer beheld "lesser lights" stuck in a solid firmament solely for the service of man, the astronomer knows that his eye beholds objects at a distance of millions upon millions of miles, objects whose grandeur throws our whole solar system into insignificance. An abstract idea is in itself capable of containing a volume of knowledge; its capacities have hardly any limits but that of the mind itself. Think only of the world of concepts contained in the words "political economy," "vertebrata," "liberty," "Aryan race," "mythology," "ethics," and we see how far civilized man has outstripped, not only the lower animals, but the young of his own race and the savage; but *the break is not at the minds of the lower animals.* Rather there is no break, but a gradual evolution.

We may take as another instance of simple, complex and abstract ideas the idea of one particular dog in the mind of the child; the idea of dogs in general, extended to figures or pictures of dogs; and the ideas of the genus "Canis" as present to the mind of the zoologist. The first and second conceptions are common to the young child and the lower animals; the third transcends the power of either. The extension of simple ideas was amazingly illustrated by a little French child, who was warned not to touch fire and candles by the words "Ca brule." This idea she spontaneously applied to other shining objects. Her mother and nurse also amused her by hiding and saying "Coucou." Watching the sun set one evening the child generalized the ideas of shining, burning and of hiding, by exclaiming "Ca brule, coucou."

A terrier has a very simple idea as to a rabbit; to catch it and kill it anyhow and anywhere. But he also has a general idea of rabbits, as may be demonstrated by calling his attention to this idea if he is out for a walk, when a violent scampering, barking and digging for imaginary rabbits may be expected to take place. A dog formerly in the possession of the Archbishop of Canterbury had the habit of hunting pigs, and for inscrutable reason, always after prayers. After a time there were no more pigs to be hunted in the flesh, but at the word "pigs" the dog vehemently hunted imaginary pigs.

Finally it was enough to open the door, without uttering a word, and the dog rushed to his visionary pig hunt.

A dog belonging to Mr. Romanes' sister showed that it not only had an idea of men and women, but that it could recognize that which was like a human being and yet was *not* one. This dog showed the utmost terror at the appearance of three life-sized pictures. But instead of attacking them with tail erect, as he would have attacked a strange person, he "barked violently and incessantly at some distance from the paintings, with tail down and body elongated, sometimes bolting under the chairs and sofas in the extremity of his fear, and continued barking from there." When the faces of the pictures were covered he became quiet and contented, but resumed his frightened barking if one was uncovered. Gradually he became accustomed to the pictures, and after a time he was taken away from the house for some months. On returning, he was again much startled at seeing the pictures, and rushed at them barking. Very quickly though he appears to have reasoned that he had seen these strange things—that were and were not men and women—before, and that they had proved harmless, for "after three or four barks he ran back to me with the same apologetic manner he has when he has barked at a well-known friend by mistake."*

If we arbitrarily confine the definition of "reason" to the power of putting our ideas into *words*, then of course animals must be denied the faculty of reason, as they do not possess that of articulate speech. But if to "reason" be to form ideas in the mind; to class them together; to be influenced by them; to act upon them, then animals possess reason. And the extent of reasoning faculty depends upon the development of the brain; on its comparative richness in convolutions and on its cultivation by education in animals as well as in men.

The difference in degree is enormous, but differences in degree do not destroy homologies in zoological classification. An elephant's nose is still a nose, though it is prodigiously elongated, and serves as a tactile and prehensile organ.

It is not that man has one particular organ highly specialized; immense numbers of animals have organs highly specialized; the foot of the horse; the fore limbs of the bat; the whole skeleton of the whale are conspicuous instances. In man the specialization has been in the brain, and this has made him the master of creation, but the difference between the brain of man and of apes is not so great as the difference between the foot of the horse and that of the elephant. Yet the difference being not between foot and foot, but in the very organ of thought itself, the effect is incalculable in producing superiority of the one animal over the other.

It has been asserted that we can form no general ideas without words. It is true that we so commonly put our ideas into words that we may be tempted to identify the one with the other. But deaf mutes who have been educated have related their mental experiences when untrained, and they describe themselves as "thinking in pictures." I have had a similar experience in meeting with two plants in the forest of British Columbia; one attaining almost to the dimensions of a forest tree, the other no larger than our wood anemone, yet agreeing exactly in the botanical peculiarity of their flowers. I know now that these plants belong to the genus Cornus, but I did not ascertain this fact for many months, and in the mean time I thought of these plants *in pictures* in which I was vividly conscious of their peculiarities. And where the mind is unable to avail itself of articulate language, this faculty of thinking in pictures may be carried to a point far beyond what we may imagine credible; just as the tying of knots in strings in a particular fashion served as whole books of history to the Peruvian Indians who were unacquainted with writing.

Moreover, though unable themselves to employ articulate language, the higher animals have the mental advantage of being able to understand and remember spoken words.

It is estimated that the more intelligent elephants in government employ in India and Ceylon understand more than eighty words and phrases addressed to them by their keepers. This statement is the more credible when we consider the diversity of occupations in which trained elephants are engaged.

The most striking instance I know of bearing on the reasoning powers of these sagacious animals is given in Mr. Romanes' work on Animal Intelligence,† on the authority of Mr. Bingley:

"In the last war in India a young elephant received a violent wound in its head, the pain of which rendered it so frantic and ungovernable that it was found impossible to persuade the animal to have the part dressed. Whenever any one approached it ran off with fury, and would suffer no person to come within several yards of it. The man who had the care of it at length hit upon a contrivance for securing it. *By a few words and signs* he gave the mother of the animal sufficient intelligence of what was wanted; the sensible creature immediate seized her young one with her trunk, and held it firmly down, though groaning with agony, while the surgeon completely dressed the wound; and she continued to perform this service until the animal was perfectly recovered."

When we consider the passionate devotion of the female elephant to her young one, and the fury with which she will defend it from injury or danger, it is almost impossible to admire too highly the reasoning powers, the self-control and the intelligent comprehension of words by this mother, under circumstances which would severely try all these qualities in a human parent.

It is well known that elephants patiently, and even gratefully, endure painful operations performed on their own persons, such as the cutting open and dressing of deep ulcers and the dropping of nitric acid in the eye. Yet the same animal would deeply resent the slightest intentional injury, such as the prick of a pin, and would lose no opportunity of revenge.

The account of the extraordinary intelligence shown by the trained elephant "Siribeddi" in the capture of wild elephants, is too long to be given here, but will richly repay perusal. [Animal Intelligence, p. 402.] Her comprehension of everything required of her; her original ideas of what should be done on the spur of the moment; her intense enjoyment of the sport; her Delilah-like duplicity toward her male captives; her extreme care to avoid injuring the prisoners; all show an intelligence not below that of a human hunter, while in her care to avoid injuring her captives she puts the human hunter to shame.

In the parrot, low as it is in the psychological scale, compared to the higher mammals, we have examples of the comprehension of words uttered by the animal itself. Mr. Darwin gives an instance of a parrot belonging to the father of Admiral Sir J. Sullivan, which invariably called certain persons of the household, as well as visitors, by their names.

He said "Good morning" to every one at breakfast, and "Good night" to each as they left the room at night, and never reversed their salutations. To his master he used to add to the "Good morning" a short sentence, never repeated after his master's death. He scolded a parrot which had got out of its cage and was eating apples on the kitchen table, calling it "You naughty Polly." Similar instances of the proper application of spoken words could be indefinitely multiplied, but I will only quote the account given by Dr. Samuel Wilkes, F.R.S., of his own parrot, which he carefully observed.* He says that when alone this bird used to "utter a long catalogue of its sayings, more especially if it heard talking in the distance, as if wishing to join in the conversation, but at other times a particular word or phrase is only spoken when suggested by a person or object. Thus, certain friends who have addressed this bird frequently by some peculiar expression, or the whistling of an air, will always be welcomed by the same words or tune, and as regards myself, when I enter the house—for my footstep is recognized—the bird will repeat one of my sayings. My coachman coming for orders has so often been told 'half-past two,' that no sooner does he come to the door than Poll exclaims 'half-past two!' Having found her awake at night I have said 'Go to sleep,' and now if I approach the cage after dark the same words are repeated. Then as regards objects, *if certain words have been spoken in connection with them, these are ever after associated together.* For example, at dinner time the parrot, having been accustomed to have savory morsels given to her, I taught her to say, 'Give me a bit.' This she now constantly repeats, but only and appropriately at dinner time. The bird associates the expression with something to eat. Again, being very fond of cheese, she easily picked up the word, and always asks for cheese at the end of the dinner course, and at no other time. She is also fond of nuts, and when these are on the table she utters a peculiar squeak: this she has not been taught, but it is Poll's own name for nuts, for the sound is never heard until the fruit is in sight. Some noises which she utters have been obtained from the objects themselves, as that of a corkscrew at the sight of a bottle of wine, or the noise of water poured into a tumbler, on seeing a bottle of water. The passage of the servant down the hall to open the hall door suggests a noise of moving hinges, followed by a loud whistle for a cab."

No animal hitherto under observation in England has shown a more remarkable comprehension of spoken words than the chimpanzee lately in the Zoological Gardens, London. This ape learned from her keeper so many words and phrases that in this respect she resembled a child shortly before it begins to speak. Moreover, it was not only particular words and phrases which she thus learnt to understand, but to a large extent "she understands the combination of these words and phrases into sentences, so that the keeper is able to explain to the animal what it is he expects her to do. For example, she will push a straw through any particular mesh in the net work of her cage which he indicates by such phrases as 'the one nearest your foot; now the one next the keyhole; now the one above the bar,' etc., etc. Of course there is no pointing to the places thus verbally designated, nor is any order observed in the designation. The animal understands what is meant by the words alone, and this even when a particular mesh is named by the keeper remarking to her the accident of its having a piece of straw already attached to it."

This chimpanzee could also count correctly as far as five. She was asked for two straws, five straws, one straw, etc., no order being observed in the requests. If she were asked for four straws she successively picked up three straws and put them in her mouth, then she picked up the fourth and handed over all the four together; the ape having been taught, if more than one straw were asked for, to hold the others in her mouth until the sum was completed.

The crow is little behind the chimpanzee in arithmetical genius if Monsieur Leroy Ranger, at Versailles, is to be trusted, and as his life work consisted in watching the wild and tame animals of the royal domain, he was hardly likely to be deceived. He says, "Crows will not return to their nests during daylight, if they see any one waiting to shoot them. If to lull suspicion a hut is made below the rookery and a man conceals himself in it with a gun, he waits in vain if the bird has ever before been shot at in a similar manner. She knows that fire will issue from the cave into which she saw the man enter. To deceive these suspicious birds, the plan was hit upon of sending two men into the watchhouse, one of whom passed on, while the other remained. But the crow counted and kept her distance. The next day three went, and again she perceived that only two returned. In fine, it was found necessary to send five or six men to the watchhouse in order to put her out of her calculations."

The ape and the crow here contrast advantageously with savages who can only count up to one and two, and with the Dammaras, who apparently can count only one. In buying sheep from a Dammara one must pay for each sheep separately, for if a stick of tobacco is the price agreed on for a sheep, it would sorely puzzle the simple savage to take two sheep and give him two sticks.† One stick must be paid for each sheep separately.

Of the intelligence of the special friend of man in the understanding of spoken words innumerable instances could be given, and many will, no doubt, recur to the mind of any person who has ever owned or watched a dog. Hogg, the "Ettrick Shepherd," had a collie who understood most things his master said to him. On one occasion Hogg observed in the most natural tone possible, "I'm thinking the cow's in the potatoes." Immediately the dog, which had been lying half asleep on the floor, jumped up, ran into the potato field, round the house and up the roof to take a survey; but finding no cow in the potatoes, lay down again. Some little time afterward his master said in a tone of conviction: "I'm sure the cow's in the potatoes," when the same scene was repeated. But on trying it a third time, the dog only wagged its tail. I had a rough terrier named "Butts" which had, like most dogs, a horror of a bath. If the fatal words, "Butts must be washed," or "Butts must have a bath," were uttered in his presence, he would, like the "Snark," slowly and silently vanish away, and would be found—if

* Origin of the Fittest. Cope.

* Romanes: Animal Intelligence, p. 456.

† Animal Intelligence, International Scientific Series, p. 399.

* Romanes: Mental Evolution in Man, p. 131.

† Galton: Tropical South Africa.

found at all—cowering under the remotest of beds, trembling with apprehension.*

From the comprehension of spoken words (with their imitative use by parrots) we come to the question of the *origin* of language. Did it spring from the human mind, ready equipped for all uses, like Minerva from the brain of Jove? Or was its origin as simple and as humble as evolution has shown the early beginnings of other things to be?

In studying the evidence for mental evolution supplied by language, it is essential to begin with the most primitive forms known to us. Instead, therefore, of having recourse to Sanskrit and kindred Aryan languages, the product of the mental processes of the highest race of man, we must examine the forms of speech of primitive people, and of semi-civilized and savage tribes. Here again ontogeny may take us further and deeper than phylogeny, and problems which have puzzled the learned may find their solution in the nursery.

The dawning wishes and desires of an infant are expressed by indeterminate movements of the legs and arms. A vigorous kicking of the legs will express the joy of a healthy baby at being taken from a place of which it is tired to a fresh room, or out of doors. Perhaps the first determinate movement that can be noticed is the forward movement of the arms with the hope of being taken by father, mother or nurse, and the next the stretching out of the hands for some coveted object, both occurring very early in a healthy baby. The frustration of these desires, as most of us know to our cost, is accompanied by most piercing vocal demonstrations indicating pain, anger or disappointment. I cannot help regarding these vocal demonstrations as survivals from the mode of expressing himself "*Homo alalus.*" And if Miocene man roared and screamed as lustily in proportion to *his* size as does our modern baby, the din must have been truly appalling, and calculated to strike terror into the heart of the mastodon himself.

Among the lower animals the eager jumping of a dog when he is anxious to go for a walk, his growling, howling and barking to express various emotions, are on a similar psychological level with the first demonstration of wishes on the part of the infant. Some of the signs and sounds expressed by domestic animals are indeterminate and some determinate, and every owner of a dog or cat can supply examples for himself.

The next step in advance taken by the infant is the utterance of articulate sounds; first various vowels and labials, *vaguely uttered without definite meaning;* then similar sounds with a definite meaning, as mamma, dada, tata, etc. These early sounds have a very extended meaning, as in Chinese the same word "bye-bye" means bed and bed clothes, sleep and to go to sleep. But as the application of these simple syllables is usually taught to the child we are not quite at the standpoint of primitive man, who had no one to teach him. There are three different sets of opinions as to the origin of spoken words, which have been named the "Pooh-pooh," the "Bow-wow" and the "Yo-heave-o" theories respectively. The first assigns the origin of language to interjectional sounds the second attributes it to imitation of cries of animals and sounds in nature, and the third considers speech arose from the various noises made by men during concerted action. A fourth assumes language to be a heaven-sent gift and that primitive language began with abstract ideas. Applying the inductive method of reasoning and watching the development of speech in infants and the condition of language in low savages, we can hope to form some idea as to how much or how little truth there is in the above theories. We shall probably come to the conclusion that the first two theories account for a considerable number of words, and that "Bow-wow" or imitative language may have given rise to many words whose imitative origin is now obscured. But watching, as before, the progress of the child, we find that *it possesses a faculty hardly, if at all, used by its elders, of coining new words* to suit its own convenience. These words will in many cases be utterly different from the words which the child hears grown-up people apply to an object, yet the new word, having been coined by the child, will be rigidly applied to the particular object or action it was first applied to. Mr. Romanes gives several instances of children who possessed this faculty to a remarkable degree, up to the point, indeed, of speaking a language of their own invention. One case is that of twin boys living in a suburb of Boston, "who, at the usual age, began to talk, but strange to say, not their mother tongue. It was in vain that a little sister five years older than they tried to make them speak in ordinary English.† They had a language of their own, and no pains could induce them to speak anything else. Not even the usual first words 'papa,' 'mamma,' did they ever speak. In fact, though they had the usual affections, were rejoiced to see their father at his returning home each night, playing with him, etc., they would seem to have been otherwise completely taken up with each other. They passed the day playing and talking together in their own speech with all the liveliness and volubility common to children. They had regular words, a few of which the family learned to distinguish, as that for example for carriage, which was 'ni-si-boo-a,' of which the syllables were sometimes so repeated as to make a much longer word." The next case is quoted from Dr. E. Hun, who recorded it in the monthly *Journal of Psychological Medicine.* "The subject of this observation is a girl aged four and a half, sprightly, intelligent and in good health. It was observed she was backward in speaking, and at two years old only used the words 'papa,' 'mamma.' After that she began to use words of her own invention, and never employed the words used by others. Gradually she enlarged her vocabulary. She has a brother eighteen months younger than herself who has learned her language, so that they can talk freely together. He, however, seems to have adopted it only because he has more intercourse with her than with the others; he will use a proper word with his mother, and his sister's with her."

The mother has learned French, but never uses that language in conversation, and the servants speak English without any peculiarities. "Some of the words and phrases have a resemblance to French, but it is certain that no person using that language has frequented the house. Of words formed by imitation of sounds the language shows hardly a trace. The mewing of the cat evidently suggested the word 'mea,' which signified both cat and furs. In some of the words the liking which children and some races of men have for the repetition of sounds is apparent. Thus we have 'migno-migno,' signifying water, wash, bath; 'go-go,' delicacies, as sweets or dessert; and 'waia-waia,' black, darkness, or a negro." "Gummigur," we are told, signifies all the substantials of the table, such as bread, meat, vegetables, etc., and the same word designates the cook. A number of additional instances of this strange vocabulary are given.* "They show," says Mr. Romanes, "that the spontaneous and arbitrary word-making which is more or less observable in all children begining to speak may, under favorable circumstances, proceed to an astonishing degree of fullness and efficiency; that, although the words thus invented are sometimes of onomatopoetic origin, as a general rule they are not so; that the words are far from being always monosyllabic;† that they admit of becoming sufficiently numerous and varied to constitute a not inefficient language; and that the syntax of this language presents obvious points of resemblance to the gesture language of mankind." This faculty of coining fresh words, now almost lost by adults, must once have existed as a normal state of things among human beings or it would not survive in the child.

Next to the impression made upon cells by their environment, producing the most profound and extraordinary changes of structure and functions, nothing can be more strange than the persistent heredity or atavism in cells. We can find a parallel for these two opposing forces in the centrifugal and centripetal forces which keep the planets in their orbits. What millions of ages must have elapsed since the ancestors of man diverged from the primeval worm-like hermaphrodite form! Yet not only do numerous organs survive in a more or less rudimentary condition, pointing conclusively to this origin, but there is every now and then a strange relapse to the hermaphrodite condition. The branchial arches found in every mammal with loops of blood vessels running up to them point to an ancestry less remote, yet for all that almost unimaginably far away in the past. The pineal gland, deep hidden under the immensely developed brain of man, still tells of a third eye which could once look through an opening in the skull. And a small bone of the wrist, of no imaginable use to any mammal at present, may be a survival of an amphibian ancestor's sixth finger. So we may well believe that the faculty of fresh word-making which is being killed out in our children by the use of language ready made in all around them is capable of a sudden revival. No doubt many of my readers will recall from their own experience the power of coining fresh words possessed by their children, and the curious reduplication of syllables employed by them. We may conclude that if Miocene man did not coin fresh words for himself and insist upon employing them as he chose, he was incapable of doing what his young descendant can do every day.

With regard to the theory that abstract terms were the first words used, we have not only the objection that all abstract terms used by us can be traced back to material objects and actions; and the objection that no one could have understood ready-made abstract terms without a miracle; but the still stronger argument that numberless savage and semi-savage peoples cannot understand and do not use abstract terms to this day. Even so simple an abstract idea as "tail" or "tree" is beyond the scope of their minds. Numerous instances of this fact are given by Mr. Tylor in his Primitive Culture, but I will cite some of those given by Mr. Romanes. "The Society Islanders have names for dog's tail, bird's tail, sheep's tail, etc., but no word for tail itself, *i. e.*, tail in general. The Mohicans have words to signify different kinds of cutting, but no verb 'to cut;' and forms for 'I love him,' 'I love you,' etc., but no verb 'to love;' while the Choctaws have names for different species of oak, but no name for the genus 'oak.' Again, the Australians have no name for tree or even for bird, fish, etc., and the Esquimau, although he has verbs which signify to fish seal, to fish whale, etc., has not any verb 'to fish.' 'Les langues,' De Ponceau remarks, 'généralisent rarement,' and he shows they have not even any verb to imply 'I will' or 'I wish,' although they have separate verbal forms for 'I wish to eat meat,' 'I wish to eat soup;' neither have they any noun substantive which signifies 'a blow,' although they have a variety which severally mean blows with as many different kinds of instruments." Similarly Mr. Crawford tells us "the Malay is very deficient in abstract words; and the usual train of ideas of the people who speak it does not lead them to make a frequent use even of those they possess. With this poverty of the abstract is united a redundancy of the concrete," and he gives many instances of the same kind as those cited from other languages. So likewise we are told "the dialect of the Yubes is rich in nouns denoting different objects of the same genus, according to some variety of color or deficiency of members or some other peculiarity, such as 'white cow,' 'brown cow,' 'red cow;' and the Sechuano has no fewer than ten words, all meaning 'horned cattle.' Cherokee presents thirteen different verbs to signify different kinds of washing without any to indicate washing itself. The Tasmanians had no words representing abstract ideas; for each variety of gum tree, wattle tree, etc., they had a name, but none for tree; neither could they express abstract qualities, such as hard, warm, soft, cold, long, short, round. A Kurd of the Yuga tribe who gave Dr. Latham a list of native words was not able to conceive of a hand or father except so far as they were related to himself or to some one else."

In Prof. Duncan's learned Analysis of the Cherokee Language he confirms the view that savage tribes cannot express such simple abstract terms as "hand" or "write." He says, "Human language is not always or necessarily *expressive;* it is sometimes merely *suggestive.* In the lower grades of social life the words are generally few in number and limited in meaning. Many of them can, indeed, hardly be called words; they are more like unintelligible exclamations whose office it is not to imprint an idea or a thought upon the apprehension of the person addressed as do the words of a cultured tongue, but rather to arrest the attention and direct it to the subject in hand, leaving the desired impressions to arise in his mind as the result of his observation and reflection. In these rudimentary tongues sentences are to be found in an embryonic state. The Cherokee is not aware that his language contains any word for hand; it is always 'aquay ăn ĕ" (my hand): that is, the idea of hand is always attended in expression with a conception of the person to whom it belongs. Now, if we should resolve this word and assign to each idea its respective part, it would stand thus: 'Aqua ayăn ĕ' (my hand), yet if these words should pass under the eyes of a Cherokee he would doubtless fail to recognize them and be apt to repudiate them as something foreign to his native vocabulary.

"While what we have said here is largely true in reference to the nouns, it is much more so as to the verbs. The Cherokee never expresses the idea of an action except in connection with that of the actor, and often of the person acted on. And the adjective in expressing a quality seldom loses sight of the object to which it belongs." Speaking of the Cherokee word signifying write, Prof. Duncan says: "It is to be doubted whether it was ever heard or written except in such conglomeration of vocables as 'Wĕtsóyawēlĕntóyĕ,' of which the portion 'awăl' conveys the idea of writing or drawing."* In its abstract state the word would, however, be quite unintelligible and requires combination with various pronouns, tense and mood signs before it can be understood or used by a Cherokee.

It is not contended, of course, that a savage *has* no general or abstract ideas because he *may* be incapable of expressing them. Animals have general ideas which they cannot express in language. And the savage who has no name for trees would be extremely surprised if he saw one standing on its tips with its roots in the air; one may be sure he has a general idea of a tree, with its roots in the ground and its tip toward the sky.

In the same way the horses and camels at Batoura, which were inordinately terrified at the first sight of a carriage and pair, knew they saw something quite fresh and unaccustomed, though they had no word for it. And the horses and cattle which have grown accustomed to trains have a general idea that the rushing, screaming, roaring object is perfectly harmless, though they cannot say so. Moreover, they acquire this conviction from experience.

If, then, we can accept ontogeny as a guide in understanding the primitive beginnings of human speech, we may conclude that the steps consisted of screaming, varied in tone as fear or anger was to be expressed; vague labials formed by the passing of the air through the lips and gums; then labials uttered with a distinct purpose, followed in many cases by *new words invented by the child for objects.* My efforts to induce a child of my own to say "milk" resulted in the invention of the word "ningey" for that article of diet, and the attempt to teach two other children to say "nurse" resulted in the christening of that functionary as "wo" and "nan," respectively; in fact, the invention of a completely new word is as easy for a child as it is notoriously difficult for an adult human being.

One of the most extraordinary boundaries that could have been selected as the "Rubicon of mind" has been fixed in the possession of a verb which once expressing such simple concrete ideas as "to stand," "to breathe," has acquired the abstract signification "to be." "If a brute could think 'is,' brute and man would be brothers." Here is the point where instinct ends and reason begins. It is not possible to produce a brute which can *say* "is" (whatever it may think), for the simple reason that brutes do not employ articulate language. But the languages belonging to the highest ancient civilizations, as "well as the languages of the savages, have also no word for 'is.'" Taking one instance only, the Coptic, it has been observed,† "what are called the auxiliary and substantive verbs in Coptic are still more remote from all essential verbal character than the so-called verbal roots. On examination they will almost always be found to be articles, pronouns, particles or abstract nouns, and to derive their verbal functions entirely from their accessories or from what they imply. In fact, any one who examines a good Coptic grammar or dictionary will find there is nothing formally corresponding with our 'am,' 'art,' 'is,' 'was.' The Egyptians had, however, at least half a dozen methods of rendering the Greek verb substantive when they desired to do so. Instead of saying 'Petrus est,' 'Maria est,' 'Homines sunt,' it is quite sufficient and perfectly intelligible to say 'Petrus hic,' 'Maria hoce,' 'Homines hi.' The above forms, according to Champollion and other investigators of ancient hieroglyphics, occur in the oldest known monumental inscriptions, showing plainly that the ideas of the ancient Egyptians as to the method of expressing the category 'to be' did not accord with those of some modern grammarians. . . . . Every Semitic scholar knows that personal pronouns are employed to represent the verb substantive in all the known dialects, exactly as in Coptic, but with less variety of modification. . . . . The phrase 'Ye are the salt of the earth,' is in the Syriac version 'You they (*i. e.*, the persons constituting) the salt of the earth.' Nor is this employment of the personal pronoun confined to the dialects above specified, it being equally found in Basque, in Gala, in Turco-Turanian, and various American languages. . . . .

"Malayan, Japanese and Malagassy grammarians talk of words signifying to be; but an attentive comparison of the elements which they profess to give as such shows clearly that they are no verbs at all, but simply pronouns or indeclinable particles commonly indicating the time, place or manner of the specified action or relation. . . . . A verb substantive such as is

* I have lately had the privilege of making the acquaintance of a dog called "Peter," who undoubtedly understands spoken words, and not only special tones. Certain words uttered by complete strangers to Peter result in his performance of certain actions, such as "dying for his queen," fetching slippers, shutting the door, walking and jumping through a hoop, etc., etc. The dog's whole face is quivering with intelligent excitement when he is spoken to.

† Paper read by Mr. Horatio Hale, published in the Proceedings of the American Association for the Advancement of Science, vol. xxxv., 1886.

* Mental Evolution of Man, p. 140.

† Where a child uses a monosyllabic word, it constantly doubles the syllable.—A. B.

* *American Naturalist*, p. 775, September, 1889.

† Garrett on the Nature and Analysis of the Verb. Proc. Philo. Soc., vol. iii.

commonly conceived, vivifying all connected speech and binding together the terms of every logical proposition, is much upon a footing with the phlogiston of the chemists of the last generation—*vox et præterea nihil*. . . . If a given subject be 'I,' 'thou,' 'he,' 'this,' 'that,' 'one;' if it be 'here,' 'there,' 'yonder,' 'thus,' 'in,' 'on,' 'at,' 'by;' if it be 'sits,' 'stands,' 'remains,' or 'appears,' we need no ghost to tell us that it *is*, nor any grammarian or metaphysician to proclaim that recondite fact in formal terms."

It seems, then, that no more unfortunate point could have been chosen than the use of the verb "to be" as constituting the Rubicon of mind; it has only served to accumulate proofs that there is no Rubicon in the sense of a distinct barrier between the minds of men and animals, and that if a dividing line be arbitrarily drawn it must not be between man and brute, but between the lower animals, young children and savages on the one hand and civilized man capable of true abstract ideas on the other.

A young child has made a distinct step in advance when he speaks of himself in the first person. But many tribes of savages have never yet risen to this consciousness of the "ego;" but for such an expression as "I will eat the rice" we have recourse to the form "The eating-of-me-the-rice."*

If a child exclaims "black man" at the sight of a negro, he expresses the same idea that we do in saying, "that man is black;" if he says "dit ki" (sister is crying), "dit dow ga" (sister is down on the grass), "dat a big bow-wow" (that is a large dog),† he is implicitly predicating certain facts and forming certain judgments precisely as if he formally used the copula. "The child perceives a certain fact and states the perception in words *in order to communicate information of the facts to other minds*, just as an animal under similar circumstances will employ a gesture or vocal sign." A cat cannot express in words the ideas "my kitten is shut in a drawer; you can take it out if you come;" but she can eloquently express her meaning by vocal signs and gestures.

Another clew to the evolution of language may be found in the sign language of educated deaf-mutes and its grammatical construction. The deaf-mute does not make the statement "bring a black hat," but "hat black bring;" not "I am hungry, give me bread," but "hungry, me bread give." The Abbé Sicard says: "A pupil to whom I put this question, 'Who made God?' replied, 'God made nothing.' I was accustomed to this inversion, usual among the deaf and dumb, and I went on to ask him 'Who made the shoe?' and he answered, 'The shoe made the shoemaker.' Laura Bridgman would spell on her fingers 'that door,' 'give book,' which she had been taught, but when she made sentences for herself she reverted to the usual deaf and dumb system, 'Laura bread give,' 'water drink Laura,' to express her wish to eat or drink."

Mr. Tylor says: "The gesture language has no grammar properly so called; it knows of no inflections of any kind more than the Chinese. The same sign stands for 'walk,' 'walkest,' 'walking,' 'walked,' 'walker.' Adjectives and verbs are not readily distinguished by the deaf and dumb. 'Horse,' 'black,' 'handsome,' 'trot,' 'canter,' would be the rough translation of the signs by which a deaf-mute would state that a handsome black horse trots and canters. The deaf-mute strings together the signs of the various ideas he wishes to connect, in what appears to be the natural order in which they follow one another in his mind, *for it is the same among the mutes in different countries*, and is wholly independent of the syntax which may happen to belong to the language of their speaking friends."

With regard to the sign language of Indians Mr. Tylor says: "There is no doubt that the Indian pantomime is not merely capable of expressing a few simple notions, but that to the uncultured savage, with his few and material ideas, it is a very fair substitute for his scanty vocabulary." Forty-three examples of this gesture language are given, collected by Mr. Pehoff, as occurring between Indians of different tribes. Colonel Mallery, in his Dictionary of Indian Signs, observes: "The sign language of the Indians, and the gesture system of deaf-mutes, and of all peoples, constitute together one language—the gesture speech of mankind—of which each system is a dialect."

In Italy the power of expression by patomime is particularly strongly developed, and whole plays are carried out through the use of gestures alone, and are thoroughly enjoyed by the people. Even in England, where gestures are less used than in any other country, one is astonished at the number of ideas which we can, and do, express by gestures. Knowing the strong influence of atavism, it is a legitimate deduction from the world-wide prevalence of gesture language that gestures formed an important part of the original means of communication between human beings, and if we are to judge from ontogeny, preceded the imitation of sounds in nature and the arbitrary invention of words, and developed *pari passu* with the original howls and shrieks of primitive man. Tribes still exist whose words are unintelligible without the aid of gesture, and who are unable to carry on a conversation in the dark.

Researches into the mental faculties of civilized children and uncivilized men, as well as into the mental faculties of the highest animals, such as the elephant, the monkey and the dog, show, as was said at the beginning of this article, a difference of degree but not of kind. Immense is the distance between the mind of a Shakespeare or a Newton and the mind of a Hottentot. But the distance is also immense between the green scum, the one-celled alga of our ponds and ditches and the lordly oak; yet each belongs to the vegetable kingdom, and there is no break in the innumerable forms which fill up the wide space between the pond scum and the oak.

With regard to the theory that language is a divine gift from the very beginning bestowed upon man and denied to the lower animals, some light is thrown by the condition of what may be called "relapsed man;" those cases where children have either been reared by wolves. The whole party was dug out; the wolves were dug out and bolted; the boy was caught, bound with a rope, and after four days, sent to an English officer, Captain Nicholetts. He was kindly treated, but he never learned to speak; he would fly at children and try to bite them, and ran to eat his food on all fours. But he was friendly with a pariah dog, and would let him share his food. He would suck up a whole pitcher of milk. He never laughed or smiled, destroyed all his clothes, and in two years and a half ended his short life of piteous degradation, speaking once or twice as he lay dying the words for water and aching head.

Another child, caught in the same neighborhood, was even more savage, and would only eat raw flesh, on which he put his hands as a dog puts its fore feet. His knees and knuckles were quite hard with running on all fours. He was quite untamable, and at last lived in the village street with the pariah dogs, going every night into the jungle. A third boy, caught at Hasanpur, exhibited the same characteristics, his favorite playmates being the jungle wolves, which would caper round him and lick him. In all these cases the characteristics of relapsed man are the same; he walks and runs well on all fours, cannot be taught to speak, lives on raw food, and drinks by suction, as a horse or cow drinks.

Now if language be a God-given endowment, exempt from the usual laws of evolution, a wild boy with uninjured brain should be able to learn to speak readily; indeed, he should be able to evolve some form of speech by himself. If, however, articulate speech is the result of long ages of evolution from speechless ancestors, we can understand that the center for articulate speech in the human brain requires stimulating and cultivating from early infancy, and if not so stimulated and cultivated will fail to exercise a faculty acquired *comparatively* late in the evolution of the species. With regard to other characteristics, every little child goes on all fours, and not like any other animals, on the toes or soles of the feet, but on the knees. And every infant at first tries to "drink like a calf," putting its mouth *into* a cup to suck up the milk, and only slowly learning to drink from the edge.

It seems to me that the weight of evidence afforded by facts is in favor of the hypothesis that the human mind has followed the laws of evolution like everything else we know of in the universe; and that the apparent abyss between the intellect of man and that of the lower animals lies, as I have said before, in the nature of the organ which has been specially evolved in *Homo sapiens*.

ROSES ON A COTTAGE PORCH IN SURREY.

*Malayan and Polynesian Languages. Mental Evolution of Man, p. 313.

†See p. 206, Mental Evolution of Man.

*See Spectator, Jan. 9, 1892.

ROSE-COVERED PORCHES.

How is it that plants are often seen flourishing in cottage gardens with a luxuriance which seems unattainable in those where all conditions appear to be so much more favorable? The great masses of hepaticas, for instance, in the cottagers' gardens in some of the western shires are unsurpassed, while the clumps (sometimes almost forests) of Madonna lilies are the envy of passers-by, and the climbers by which the cottage is often half hidden seem to grow with more freedom than anywhere else. Perhaps the reason may not be further to seek than in the employment of materials well suited to the climate and conditions, for there is no doubt that common plants well grown are more decorative than half-starved specimens of more brilliant things, for whose proper cultivation the requisite means are not attainable; and a cottage porch smothered with honeysuckles and some old-fashioned roses is about as pleasant a sight as can be seen, in spite of the climbers being neither rare nor costly. But the supposition that the denizens of cottage gardens are so fine because they are indigenous or exceptionally hardy plants is not sufficient to account for the handsome subjects there so often met with; the finest Catherine Mermet I ever saw was climbing on the chimney of a cottage by the roadside in Surrey, and in a similar position in another part of the same county I have seen blooms of Gloire de Dijon such as I have never seen elsewhere, even in celebrated rose gardens. Every reader will doubtless recall Dean Reynolds Hole's description of the noble specimens upon the walls of a cottage of the glorious, but hardly to be flowered, Noisette Cloth of Gold, which so rarely gets sun enough to ripen its shoots in this climate, and even more rarely succeeds in preserving them uninjured until the flowering time. I myself have experienced the pangs of jealousy when passing a house masked with a Climbing Devoniensis in full bloom, the cultural attention to which consisted in its being occasionally gone over with a long-handled bill hook, such as is used in trimming hedges, "just to keep the shoots from rattlin' on the windows."

In spite of these seemingly anomalous instances, however, the real reason of the presence of striking specimens in cottage gardens will probably be found in the fact that, not being too numerous, each plant is

tended and looked after with the greatest care; the precious and carefully collected road scrapings, not having to be spread over a wide area, are put round special favorites to provide at once food and protection, and thus is encouraged that luxuriance of growth which renders possible the rose-covered porches of our Surrey cottages, whereby a pleasant feast of brightness is afforded to weary travelers passing by.—T. W.

It is remarkable how seldom the white rose (double or garden variety of Rosa alba) is to be seen in any but cottage gardens, and the same may be said of its near relation, the maiden's blush. Such good roses, capable as they are of highly ornamental treatment and so individually charming, certainly deserve more general culture than they receive. The white rose does equally well as a bush 5 ft. or 6 ft. high or as a low climber. The cottage porch we engrave shows it in the latter form, trained to meet a honeysuckle in the front, the training not overdone, but with that happy knack of supporting and guiding without apparently constraining that best shows the natural beauty of climbing plants.—*The Garden.*

A NEW GASEOUS INCANDESCENT LAMP.

By H. N. WARREN, Research Analyst.

THE incandescent property of platinum in most of its allotropic modifications has been noted from an early period, but, as regards brilliancy, is far inferior to such substances as, for instance, magnesia, lime, asbestos, and, lastly, zirconia.

To thus obtain a suitable thread material in order to present a substance to work a film from, probably no substance is better suited than asbestos itself, both on account of its indestructibility and also as regards its compactness and inferior conductibility of heat; but, on the other hand, asbestos possesses none of the properties of platinum with respect to incandescence. True platinized asbestos, prepared by immersing asbestos fiber in solution of platinic chloride, has been, and still is, frequently employed to promote catalysis or surface action, but in comparing its value as a lighting agent it scores very low. In this case the decomposition of the platinum salt employed destroys by rendering rotten the fabric of the asbestos, and to overcome this difficulty the author has contrived and succeeded in combining a special combination of platinum not hitherto noted in conjunction with zirconia. The

film thus employed is mounted inside the small globe, as shown by the accompanying diagram, which represents two lamps, namely, A and B, which are readily connected to each other by the short tube, C, the bottom lamp, B, being connected at D with a gas supply arranged to admit of a supply of air and gas as through an ordinary Bunsen burner, the uppermost pipe, E, intended to convey the waste gases through a suitable aperture into the open. The ignition of the film is readily brought about by applying a heated wire during the passage of the gas, and provided the gas and air supply are kept constant, several such lamps may be fed from the one gas supply.

For advertising purposes an ingenious modification of this in the form of large letters has been constructed, in which words may be maintained at a white heat, and observable at great distances. With this second invention there are still some difficulties to overcome, but by its aid the writer hopes before long to bring to the front one of the latest advertising freaks.—*Chemical News.*

ACTION OF NITRIC OXIDE UPON THE METALS AND METALLIC OXIDES.

By PAUL SABATIER and J. B. SENDERENS.

THE authors have caused nitric oxide to act at a temperature always below 500°. The gas had been prepared by the action of nitric acid upon a hot concentrated solution of ferrous sulphate; it was carefully dried and not used until it was perfectly pure. Metals not oxidizable in the air, silver, platinum, etc., are not oxidized by nitric oxide. Liquid mercury, progressively heated to ebullition, remained perfectly bright. Its vapor did not undergo any oxidation even at 450°. Aluminum (in filings) is not altered. The common metals oxidizable in the air, whether taken in a fused state, in sheets or even in filings, are oxidized only very imperfectly in nitric oxide, even if heated to a dull redness: copper, iron, cadmium, zinc, are only covered with a superficial layer of oxide. Lead is oxidized more rapidly, forming yellow litharge. It is not the same with metals obtained in a divided state on reducing the oxides by hydrogen; nitric oxide acts upon them at a temperature at which it is perfectly stable, and transforms them entirely into oxides which are usually different from those yielded by oxygen or by air. Reduced nickel heated to 200° in nitric oxide burns with brisk incandescence, yielding greenish yellow protoxide. In air the incandescence is less intense, and the protoxide is always mixed with black sesquioxide.

Reduced cobalt, if heated to 150° in nitric oxide, yields maroon-colored protoxide with lively incandescence. In air we obtain the black intermediate oxide, Co_3O_4. Iron reduced from the peroxide by a prolonged heating to redness in a current of hydrogen is oxidized in nitric oxide, beginning at 200°. The incandescence is lively, and we have a blackish gray ferrous oxide. Reduced copper is oxidized in nitric oxide at 200°, and is entirely converted into cuprous oxide, Cu_2O, of a very homogeneous cochineal red. At dull redness incandescence sets in, doubtless primed by a little oxygen which has become free; still the product is identical, but of a more brilliant color. In air the result is a formation of black CuO. Palladium sponge previously saturated with hydrogen has no appreciable action upon nitric oxide in the cold, but at 200° there is decided incandescence. The nitric oxide is then transformed totally into water and ammonia without any simultaneous oxidation of the metal. The authors have submitted to the action of nitric oxide a number of lower oxides obtained by reducing a higher oxide by means of hydrogen.—*Chem. News.*

THE SCIENTIFIC AMERICAN

Architects and Builders Edition

$2.50 a Year. Single Copies, 25 cts.

This is a Special Edition of the SCIENTIFIC AMERICAN, issued monthly—on the first day of the month. Each number contains about forty large quarto pages, equal to about two hundred ordinary book pages, forming, practically, a large and splendid **Magazine of Architecture,** richly adorned with *elegant plates in colors* and with fine engravings, illustrating the most interesting examples of modern Architectural Construction and allied subjects.

A special feature is the presentation in each number of a variety of the latest and best plans for private residences, city and country, including those of very moderate cost as well as the more expensive. Drawings in perspective and in color are given, together with full Plans, Specifications, Costs, Bills of Estimate, and Sheets of Details.

No other building paper contains so many plans, details, and specifications regularly presented as the SCIENTIFIC AMERICAN. Hundreds of dwellings have already been erected on the various plans we have issued during the past year, and many others are in process of construction.

Architects, Builders, and Owners will find this work valuable in furnishing fresh and useful suggestions. All who contemplate building or improving homes, or erecting structures of any kind, have before them in this work an almost *endless series of the latest and best examples* from which to make selections, thus saving time and money.

Many other subjects, including Sewerage, Piping, Lighting, Warming, Ventilating, Decorating, Laying out of Grounds, etc., are illustrated. An extensive Compendium of Manufacturers' Announcements is also given, in which the most reliable and approved Building Materials, Goods, Machines, Tools, and Appliances are described and illustrated, with addresses of the makers, etc.

The fullness, richness, cheapness, and convenience of this work have won for it the **Largest Circulation** of any Architectural publication in the world.

A Catalogue of valuable books on Architecture, Building, Carpentry, Masonry, Heating, Warming, Lighting, Ventilation, and all branches of industry pertaining to the art of Building, is supplied free of charge, sent to any address.

MUNN & CO., Publishers,
361 Broadway, New York.

THE SCIENTIFIC AMERICAN

Cyclopedia of Receipts,

NOTES AND QUERIES.

680 PAGES. PRICE $5.

This splendid work contains a careful compilation of the most useful Receipts and Replies given in the Notes and Queries of correspondents as published in the SCIENTIFIC AMERICAN during nearly half a century past; together with many valuable and important additions.

Over Twelve Thousand selected receipts are here collected; nearly every branch of the useful arts being represented. It is by far the most comprehensive volume of the kind ever placed before the public.

The work may be regarded as the product of the studies and practical experience of the ablest chemists and workers in all parts of the world; the information given being of the highest value, arranged and condensed in concise form, convenient for ready use.

Almost every inquiry that can be thought of, relating to formulæ used in the various manufacturing industries, will here be found answered.

Instructions for working many different processes in the arts are given. How to make and prepare many different articles and goods are set forth.

Those who are engaged in any branch of industry probably will find in this book much that is of practical value in their respective callings.

Those who are in search of independent business or employment, relating to the manufacture and sale of useful articles, will find in it hundreds of most excellent suggestions.

MUNN & CO., Publishers,
361 Broadway, New York.

THE

Scientific American Supplement.

PUBLISHED WEEKLY.

Terms of Subscription, $5 a Year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50 stitched in paper, or $3.00 bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents, and canvassers.

MUNN & CO., Publishers,
361 Broadway, New York, N. Y.

TABLE OF CONTENTS.

PAGE

I. BIOLOGY.—Long-Tailed Japanese Fowls.—Interesting example of cultivated animal peculiarities.—Fowls with tails of immense length.—1 illustration 13838

II. CHEMISTRY.—A New Gaseous Incandescent Lamp.—By H. N. WARREN.—A lamp utilizing the catalytic action between a mixture of gas and air and metallic platinum, making possible the production of designs.—1 illustration 13846

Action of Nitric Oxide upon the Metals and Metallic Oxides.—By PAUL SABATIER and J. B. SENDERENS.—A number of results obtained by experiments with this compound, using a number of metals and oxides 13846

III. CIVIL ENGINEERING.—A Short History of Bridge Building.—By C. R. MANNERS.—A supplement to this elaborate article, with interesting examples of typical and historical bridges not referred to in the main paper.—4 illustrations 13838

Mirror for Laying Out Straight Lines.—A simple device for laying out straight lines over bodies of water in surveying operations.—1 illustration 13838

IV. DIALING.—Improved Mean Time Sun Dial.—A very ingenious modification of the sun dial, so arranged as to compensate for the equation of time.—1 illustration 13849

V. ELECTRICITY.—A Fatal Thunderbolt at Bourges, France.—A most remarkable lightning discharge, and its effects on the clothing of one of the victims.—2 illustrations 13835

Insulation.—By THOMAS A. EDISON.—A valuable paper by the great electrician, reviewing insulation from the standpoint of the telegrapher 13851

VI. HORTICULTURE.—Rose Covered Porches.—Beautiful examples of flower culture in cottages in England, and the reasons for the success.—1 illustration 13845

VII. METALLURGY.—Blue Brass.—A method of coloring brass a deep blue, with notes of the alloy best suited for its operation 13838

The Cyanide Process for Working Gold and Silver Ores without amalgamation.—Full details of the MacArthur-Forrest process, with results attained by it and plan of the works.—1 illustration. 13838

The MacArthur Metallurgical Filter.—A metallurgical filter for separating precious metal from their solutions obtained in different metallurgical processes.—2 illustrations 13837

VIII. MISCELLANEOUS.—A London Ivory Sale.—A very curious auction sale taking place four times a year in London.—A graphic account of the entire proceeding, and of the general properties of the material and its uses in commerce.—1 illustration 13839

On the Uncertainty of Conclusions.—By T. C. MENDENHALL.—A most striking paper, touching on the unreliability of circumstantial evidence.—Of special application to science 13849

Rat Catching.—An English rat catcher's experience, and notes of a recent publication by a professional rat catcher.—A very graphic presentation of this curious subject 13838

The Fourth Centenary of Columbus.—Interesting notes concerning Columbus' first voyage, his ships, and his wonderful skill as a navigator 13841

IX. NAVAL ENGINEERING.—Oil Engine and Launch.—An oil gas engine, and the launch propelled by same, built in England 13851

X. PSYCHOLOGY.—Mental Evolution in Man and the Lower Animals.—By ALICE BODINGTON.—Extraordinary instances of animal intelligence in elephants, the chimpanzee, and other animals.—Curious examples of human mental operations.—A most interesting presentation of the subject 13843

XI. RAILROAD ENGINEERING.—The Pneumatic Motor for Surface Roads.—By HERMAN HAUFT.—A plea in favor of pneumatic car propulsion, with estimates of costs and capitalization 13851

XII. TECHNOLOGY.—Decorticating Ramie.—Chemical treatment of ramie fiber by a new series of salts 13835

Lamp Black and Bone Black.—By HENRY J. WILLIAMS.—Method and manufacture of these products, their composition, and quality.—1 illustration 13850

A New Catalogue of Valuable Papers

Contained in SCIENTIFIC AMERICAN SUPPLEMENT during the past ten years, sent *free of charge* to any address. MUNN & CO., 361 Broadway, New York.

Useful Engineering Books

Manufacturers, Agriculturists, Chemists, Engineers, Mechanics, Builders, men of leisure, and professional men, of all classes, need good books in the line of their respective callings. Our post office department permits the transmission of books through the mails at very small cost. A comprehensive catalogue of useful books by different authors, on more than fifty different subjects, has recently been published, for free circulation, at the office of this paper. Subjects classified with names of authors. Persons desiring a copy have only to ask for it, and it will be mailed to them. Address

MUNN & CO., 361 Broadway, New York.

PATENTS!

MESSRS. MUNN & CO., in connection with the publication of the SCIENTIFIC AMERICAN, continue to examine improvements, and to act as Solicitors of Patents for Inventors.

In this line of business they have had *forty-five years' experience,* and now have *unequaled facilities* for the preparation of Patent Drawings, Specifications, and the prosecution of Applications for Patents in the United States, Canada, and Foreign Countries. Messrs. Munn & Co. also attend to the preparation of Caveats, Copyrights for Books, Labels, Reissues, Assignments, and Reports on Infringements of Patents. All business intrusted to them is done with special care and promptness, on very reasonable terms.

A pamphlet sent free of charge, on application, containing full information about Patents and how to procure them: directions concerning Labels, Copyrights, Designs, Patents, Appeals, Reissues, Infringements, Assignments, Rejected Cases. Hints on the Sale of Patents, etc.

We also send, *free of charge,* a Synopsis of Foreign Patent Laws, showing the cost and method of securing patents in all the principal countries of the world.

MUNN & CO., Solicitors of Patents,
361 Broadway, New York.

BRANCH OFFICES.—No. 622 and 624 F Street, Pacific Building, near 7th Street, Washington, D. C.

92.

nt.

n any
lars a

m the
Price,

n like-
early.
$3.00

MERI-
PPLE-

s, and

. Y.

PAGE
of
ase 1959
N.
ix-
he 1956
—
its
of 1950
—
ith
re- 1947
ay-
ra- 1943
ua
he 1942
A
sh-
he 1934
he
m-
for 1945
a s
out 1923
ss,
n. 1935
for
er- 1927
ous
hic
of 1920
—
m- 1940
tes
ery 1938
ro-
s a 1941
ras 1931
ni-
ni-
als.
er- 1943
ur-
tic 1921
ent 1939
—
on, 1933

pers

MENT
o any
ork.

ks

neers,
sional
their
ermits
t very
books
t sub-
ation,
with
e only
ress

York.

S!

he pub-
examine
nts for

ect, and
rawings,
in the
Co, also
Labels,
ats. All
ness, on

l infor-
ncerning
rements.

s, show-
ountries

nilding,